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DESIGN MECHANICAL PROPERTIES, FRACTURE TOUGHNESS, FATIGUE PROPERTIES, EXFOLIATION AND STRESS-CORROSION RESISTANCE OF 7050 SHEET, PLATE, HAND FORGINGS, DIE FORGINGS AND EXTRUSIONS

ALUMINUM COMPANY OF AMERICA

PREPARED FOR
NAVAL AIR SYSTEMS COMMAND

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The mechanical properties, including fracture toughness and fatigue, fatigue-crack growth rates and corrosion characteristics have been determined for a total of 51 lots of 7050-T76 sheet, 7050-T73651 plate, 7050-T73652 hand forgings, 7050-T736 die forgings and 7050-T76511 extruded shapes.

Tables of computed design mechanical properties, modulus of elasticity values, and individual stress-strain curves are presented.

The critical stress-intensity factor, K_c, was determined for samples of each lot of sheet and the plane-strain stress intensity factor, K_{Ic}, was

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Axial-stress fatigue strengths were determined in ambient-air and salt-fog environments. Modified Goodman diagrams were developed from tests made in ambient air.

Generally, equivalent rates of fatigue-crack propagation were obtained for plate, hand forgings and extruded shapes. Propagation occurred significantly faster in the longitudinal direction of thick hand forgings and extruded shapes.

All products showed a high resistance to exfoliation attack and were resistant to stress-corrosion cracking when stressed in the longitudinal and long-transverse directions; for the short-transverse direction, the various products and tempers showed good resistance to SCC in line with proposed targets. SCC performance of precracked specimens from plate, die forgings and extruded shapes showed trends similar to those obtained for smooth specimens.

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SUMMARY

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PREFACE

This investigation was conducted by Alcoa Laboratories, Aluminum Company of America, Alcoa Center, Pennsylvania, for the Department of the Navy, Naval Air Systems Command, Washington, D.C. under NASC Contract No. N00019-72-C-0512.

This report covers work done from May 12, 1972 to November 12, 1974.

This investigation was coordinated by Mr. J. G. Kaufman. The phase covering the design mechanical properties, fracture toughness and fatigue properties (ambient air) was under the supervision of Mr. D. J. Brownhill, with Mr. R. E. Davies as project engineer. The phase covering the fatigue properties (salt-fog) and fatigue-crack propagation rates was under the supervision of Mr. R. A. Kelsey, with Mr. G. E. Nordmark as project engineer. The phase covering the exfoliation and stress-corrosion characteristics was under the supervision of Mr. D. O. Sprowls, with Mr. J. D. Walsh as project leader.

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SECTION I

INTRODUCTION

The aerospace industry has a need for an aluminum alloy capable of developing in thick products a combination of high strength, high resistance to stress-corrosion and good fracture toughness for advanced, reliable, high-performance aircraft and aerospace structures. It also has a need for thinner aluminum alloy products which are capable of developing good resistance to exfoliation and high toughness at high-strength levels. Established commercial alloys and tempers provide one and sometimes two of these characteristics, but the combination of all three in either thick or thin sections has heretofore not been available.

Alcoa developed alloy 7050 under NASC contracts[1-4] to fill the need for a material which had the desired combination of properties in thick sections, and later realized that in thin sections this alloy also developed levels of strength, exfoliation resistance and toughness that were superior to those of commercial aluminum alloy products.

The alloy development work revealed that the corrosion characteristics and toughness of alloy 7050 products progressively increased as yield strength decreased with overaging beyond peak strength. This correlation between yield strength and corrosion resistance was used to select tentative minimum tensile properties for various tempers of 7050 products.

Either yield strength or corrosion resistance was used as the primary property. The secondary property was obtained from the yield strength-corrosion resistance correlation. For some products and tempers corrosion resistance capability criteria were initially set. The maximum yield strengths expected to provide the desired corrosion resistance were then estimated from tensile and corrosion test data. The minimum yield strengths were then set 9 ksi below the maximum values; this spread in yield strengths is that expected based on the fabricating and heat treating practices established for the products. In other instances, the desired minimum yield strength was initially set and the maximum yield strength was made 9 ksi higher. Then the corrosion resistance capabilities were estimated from the yield strength-corrosion resistance correlation. Once the yield strengths and corrosion resistance capabilities were set, minimum tensile ultimate strengths were established from relationships of yield strength to ultimate strength for commercially established 7XXX alloy products. Minimum elongations were estimated from available data.

The purpose of this investigation was to evaluate the mechanical properties and corrosion characteristics of 7050 products produced by commercial practices in the form of (T76) sheet, (T73651) plate, (T73652) hand forgings, (T736) die forgings and (T76511) extruded shapes. In order to make effective and efficient utilization of these products, sufficient data have been evaluated to permit the development of statistically meaningful design mechanical properties for use in MIL-HDBK-5[5] and to provide sufficient confidence in their levels of fracture toughness, fatigue strength, fatigue-crack propagation rates, exfoliation and stress-corrosion resistance.

SECTION II

MATERIAL

The 7050 products tested in this investigation included eleven lots of T76 sheet and ten lots each of T73651 plate, T73652 hand forgings, T736 die forgings and T76511 extruded shapes. All lots tested were produced by commercial practices. Three samples each of hand forgings, die forgings and extruded shapes were fabricated by another producer, hereafter designated as "Producer B"; all other samples were fabricated by Alcoa, hereafter designated as "Producer A".

The chemical compositions of each sample, determined at the Alcoa Laboratories, are shown in Table I. The compositions of all samples are within the specified limits shown at the bottom of Table I.

The tensile properties of the sheet, plate, hand forgings, die forgings, and extruded shapes are shown in Tables II, III, IV, V and VI, respectively. The specified minimum tensile properties are shown in Table VII. The AMS Specifications for plate, hand forgings and die forgings are indicated in the last column of Table VII. The minimum values for sheet and extruded shapes are Alcoa's tentative values. The tensile properties of two of the hand forgings (S. Nos. 428850 and 428851) and one of the die forgings (S. No. 411392) were initially below the specified minimum values. In each instance two retests were made. As indicated in Table IV, one of the two retests of the short-transverse specimens of the 3-1/2-in. thick hand forging (S. No. 428850) failed to meet the tensile strength minimum values by 0.8 ksi. Both short-transverse tensile strengths in the retests of the die forgings (S. No. 411392) failed to meet the minimum value (Table V). These samples could not be replaced by Producer B. Also, two of the hand forgings, and five of the die forgings had yield strengths a little above the maximum values. Since the minimum and maximum tensile properties at the time of the tests were tentative and since the relationships among the tensile, compressive, shear and bearing properties would still be valid, the data were included in the analysis of ratios for establishing minimum design properties.

Etched cross sections of each sample, except sheet, are shown in Figs. 1 through 27. The microstructures of some of the samples were examined; all structures were representative of structures of commercially established 7XXX aluminum alloys. Photographs of the die forgings are shown in Figs. 12 through 21 along with the etched cross section of the respective die forgings.

SECTION III

PROCEDURE

A. Mechanical Properties

A.1. Tensile, Compressive, Shear and Bearing

All tensile, compressive, shear and bearing tests were made using the smallest suitable range of an Amsler 20,000-lb. (Type 105XBDA58), an Olsen Electomatic 30,000-lb, and an Olsen Super-L 20,000-lb or a Southwark-Tate-Emery 50,000-lb capacity Universal Testing Machine. The machines were calibrated prior to and during the investigation. The accuracy of these testing machines was always within that required by ASTM Method E4[6].

In general, the test specimens and procedures used were, where appropriate, the same as those used in previous investigations of sheet, plate, extrusions and forgings[7-12]. Single tests were made except in a few instances where initial results indicated check tests were necessary. Specimens were taken in the test directions and locations specified in ASTM B557[13]. Specimens (L and LT) from the sheet were full thickness. Longitudinal specimens from plate were from the same locations as the long-transverse specimens, and short-transverse specimens were from the center of the thickness. Specimens from hand forgings (L, LT and ST) were from the center third of the thickness and width. Longitudinal specimens from predominantly "flanged" die forgings, 0.6 to 3.1-in. thick, were located between the parting plane and the top of the flange. Short-transverse specimens were taken normal to the parting plane with the center of the test sections located at the parting plane; specimens from the thicker die forgings, 3.5 to 6.1-in. thick (or diameter) were from the central area of the cross section; locations of the longitudinal specimens from extruded shapes were as indicated in ASTM B557 and long-transverse and short-transverse specimens were from the center of the width and thickness.

Tensile tests were made in accordance with ASTM E8[14] with either 1/2-in. wide sheet-type specimens or 1/2-in. diameter tapered-seat specimens, except where it was necessary to use subsize round specimens (Fig. 28). The yield strengths were determined from autographically recorded load-strain diagrams.

Compressive tests were made in accordance with ASTM E9[15] using a subpress (Fig. 3 of ASTM E9). Specimens from sheet and extruded shapes less than 0.500-in. thick were of the type shown in Fig. 29; these specimens were supported laterally by a Montgomery-Templin Fixture (Fig. 4 of ASTM E9). Specimens from thicker products were cylindrical of the type shown in Fig. 29. The yield strengths were determined from autographically recorded load-strain diagrams.

Shear tests of each sample of sheet were made with a punch-type shear tool in which the shear strength was determined by measuring the load required to punch a 2-3/4-in. diameter circle from a 4x4-in. blank with a hardened steel punch and die. Shear tests of the other products, and also the 0.222 and 0.249-in. sheet, were made using cylindrical specimens (Fig. 29); these specimens were tested in an Amsler double-shear tool in which a 1-in. length is sheared from the center of a 3-in. long specimen, the end thirds being supported throughout their length. In the tests of longitudinal and long-transverse specimens, the loads were applied in the direction normal (ST) to the major surface of the product; in the tests of short-transverse specimens, the loads were applied in the direction parallel (L) to the major axis[16].

Bearing tests were made in accordance with ASTM E238[17] using longitudinal and, where possible, long-transverse specimens of the type shown in Fig. 30. Specimens from material equal to or less than 0.249-in. thick were full thickness, and those from thicker material were machined to 0.094-in. thick. The bearing ultimate and yield strengths were determined at edge distance of 1.5 and 2.0 times the pin diameter. The bearing yield strength was obtained by determining the load at a permanent deformation of 2 per cent of the pin diameter as indicated on an autographic load-deformation diagram. Bearing specimens were taken flatwise with the exception that those from the hand and die forgings were taken edgewise. The specimens and test fixtures were cleaned ultrasonically as prescribed in ASTM E238.

Tensile and compressive stress-strain tests, including modulus of elasticity determinations, were made of longitudinal, and when possible, long-transverse and short-transverse specimens from five samples of each product. The tests were, in general, conducted in accordance with ASTM E111[18]. The tensile specimens were of the type shown in Fig. 31 and the compressive specimens were of the types shown in Fig. 29 (sheet-type, 3/4-in. and 1/2-in. dia.).

Loads were measured with Revere Super Precision type load cells having an accuracy, traceable to the National Bureau of Standards, of 0.1 per cent of rated output. Strains were measured with Micro-Measurements Types CEA-13-062UW-350 and CEA-13-125UW-350 strain gages. These gages have a gage factor accuracy of 0.5 per cent and a resistance accuracy of 0.3 per cent. The stress and strain signals were recorded on a Mosley X-Y recorder. Overall accuracy of load measurement was 0.5 per cent of reading or 0.25 per cent of full scale, whichever was larger. Strain measurement accuracy was 0.7 per cent of reading or 0.5 per cent of full scale, whichever was larger; the accuracy of the gages was well within the requirements established for Class B1 extensometers in ASTM E83[19].

The modulus of elasticity values were determined from Tuckerman analysis plots as described in ASTM E111. The values obtained from the stress versus strain plots were used for the trial modulus values. The specimens were tested to 25 ksi, within the elastic limit of the material. The stress scales were 2.5 ksi per inch and the strain scales were 250 microinches per inch.

The aforementioned methods and equipment were then used to obtain stress-strain curves beyond the yield strength of the material; the stress scale was 10 ksi per inch and the strain scale was 2000 microinches per inch. These data were also recorded in computer storage for use in establishing typical stress-strain and tangent-modulus curves. Compressive modulus of elasticity values from zero stress to the proportional limit were determined from these data. Presently, there are insufficient production data for establishing the typical tensile properties necessary for making typical stress-strain curves.

A.2. Fracture Toughness

The critical stress-intensity factor, K_c, of all the sheet samples were determined from tests of 16-in. wide center-slotted panels of the type shown in Fig. 32[20] following published guidelines[21]. The specimens were loaded monotonically in an Amsler 300,000-lb capacity testing machine, shown in the test setup in Fig. 33. Two different anti-buckling guides, shown in Fig. 34, were used. The improved type, shown at the bottom of Fig. 34, was used in the latter tests. The guides at the top of Fig. 34 were made up of four separate aluminum bars and the improved guides were made up of two bars with a 1x12-in. slot centered over the crack in the specimen; these guides had 1/8-in. thick layers of lubricated teflon between the guides and the specimen. A few samples were tested without anti-buckling guides.

The crack-opening displacement (COD) was measured over an 11.3-in. gage length. Plots of load versus COD were made using a Mosley X-Y recorder. The critical crack lengths were calculated by conversion of COD to crack length measurement through a compliance calibration. The critical stress-intensity factor, K_c, was calculated at the point of instability. Crack resistance curves for 0.063-in. sheet were developed. Data for 0.063-in. sheet were established using the technique proposed by C. E. Feddersen[22].

All samples were tested with 4-in. center slots. One sample of 0.063-in. sheet was tested with various slot sizes, 1, 2, 3, 4, 5 and 6 in.; the other sample of 0.063-in. sheet was tested with 4 and 6-in. slots.

Duplicate fatigue-cracked compact tension specimens of the type shown in Fig. 35 were used to determine the plane-strain stress-intensity factor, K_{Ic}, of all the plate, hand forgings and die forgings and all but the 0.187-in. thick extruded shape. The specimen orientations, shown in Fig. 36, dimensions, notches, fatigue cracking and testing procedures were essentially in accordance with ASTM E399[23]. The specimens were fatigue cracked by axial loading (R=+0.1) in Krouse fatigue machines. The test setups for fatigue precracking and fracture toughness testing are shown in Figs. 37 and 38, respectively. The tests were made in a 30,000-lb capacity Olsen Electomatic testing machine, and plots of load versus COD were recorded using a Mosley X-Y recorder. Candidate values of critical plane-strain stress-intensity factor, K_Q, were calculated using the load at 5 per cent secant offset which is equivalent to about 2 per cent of crack extension. If all the validity criteria specified in ASTM Method E399 were met, the candidate value was designated as K_{Ic}.

A.3. Axial-Stress Fatigue

A.3.1 Ambient-Air Environment

Tests were made of smooth and notched axial-stress fatigue specimens of the types shown in Figs. 39 (sheet-type, thickness $\leq$ 0.125 in.) and 40 (round). Generally, longitudinal and long-transverse specimens were taken from each product; specimens from die forgings were longitudinal and short-transverse and specimens from hand forgings were long-transverse except for one sample where specimens were taken in all three directions, L, LT and ST. The specimens were, in general, taken from the same locations as the tensile specimens. Tests were made at stress ratios* of R=+0.5, 0.0 and -1.0 for one sample each of sheet, plate, hand forgings and extruded shapes; sufficient specimens were tested in order to develop modified Goodman diagrams. Generally, at least four specimens from the other lots, including die forgings, were tested at various stress levels at a stress ratio of R=0.0. All tests were made in Krouse fatigue machines operating in 13.3, 25.0 or 28.8 Hz.

A.3.2 Salt-Fog Environment

Smooth and notched specimens having test sections similar to those shown in Figs. 39 and 40 were subjected to axial-stress fatigue tests (R=0.0) in a salt-fog environment. As indicated in Fig. 40 the notched round specimen had a notch-tip radius of 0.0005 in., $K_t \geq 12$, instead of 0.013 in., $K_t = 3$, as originally intended. Specimens were taken in the long-transverse direction from two thicknesses of the sheet, plate, hand forgings and extruded shapes. During the tests in 5-kip capacity Krouse fatigue machines operating at 18.3 Hz, the test sections were subjected to a 20-second spray of a 3-1/2 per cent salt solution at 5 minute intervals.

* Stress ratio, $R = \frac{\text{minimum stress}}{\text{maximum stress}}$

B. Fatigue Crack-Propagation Tests

Fatigue-crack propagation rates for 0.040 and 0.215-in. thick sheet samples were determined using full thickness, center-notch specimens containing a 0.020-in. long EDM (electrical discharge machining) crack-starter notch, Fig. 41. Compact tension specimens, Fig. 42, were used for the plate, extrusions and hand forgings. Data were developed for each product in: (a) Dry air, (b) Humid air and (c) 3-1/2 per cent NaCl salt fog. Specimens were taken in the T-L and L-T orientations, and where possible in the S-L orientation, as shown in Fig. 36.

Center-notch specimens were tested in a 15-kip Krouse fatigue machine, Fig. 43, at a frequency of 13.3 Hz. The compact tension-type fatigue crack-propagation specimens were tested in 5-kip Krouse machines at a frequency of 18.3 Hz using fixtures similar to those shown in Fig. 44. Fatigue cracks were generally initiated at R=0.1 at maximum test loads used in subsequent data acquisition at R=1/3. The final 0.03 to 0.05 in. of "initiation" was accomplished at test loads (R=1/3). Visual crack-length measurements were made using low power magnification (15X) and a series of reference grid lines (0.02 in.) photographically printed on both sides of the specimen surface (Fig. 44).

Environmental control was provided by using chambers such as shown in Fig. 43. Dry air (relative humidity < 10 per cent) was obtained using dessicants; humid air (relative humidity < 90 per cent) was obtained by having a water reservoir in the chamber. The salt fog consisted of a 20 second spraying of a 3-1/2 per cent salt solution applied at 5-minute intervals.

The rate of fatigue-crack growth, da/dN, was determined from the slope of a second degree polynomial fitted through each three successive data points. The rates of crack growth were plotted as a function of $\Delta K = \frac{\Delta P \sqrt{a}}{BW}$

where a = crack length, in. (half of total crack length for center-notch specimens), Figs. 41 and 42.

B = specimen thickness, in.

W = specimen width, in. (load line to end of specimen for compact tension specimen).

P = load, kips.

Y, (center-notch specimen) $= 1.77 + 0.277\left(\frac{2a}{W}\right) - 0.510\left(\frac{2a}{W}\right)^2 + 2.7\left(\frac{2a}{W}\right)^3$ (Ref. 24)

Y, (compact-tension specimen, H/W = 0.485) =

$$30.96 - 195.8\left(\frac{a}{W}\right) + 730.6\left(\frac{a}{W}\right)^2 - 1186.3\left(\frac{a}{W}\right)^3 \text{ (Ref. 25)}$$

Y, (compact-tension specimen, H/W = 0.6) =

$$29.6 - 185.5\left(\frac{a}{W}\right) + 655.7\left(\frac{a}{W}\right)^2 - 1017.0\left(\frac{a}{W}\right)^3 + 638.9\left(\frac{a}{W}\right)^4$$

C. Corrosion Characteristics

C.1. Resistance to Exfoliation

The resistance to exfoliation of the various products was evaluated by means of 2x4-in. panels machined to the T/10 and/or the T/2 planes (10 or 50 per cent of the section thickness machined from one of the fabricated surfaces) and exposed to the EXCO test per ASTM G34[26]. The EXCO test involves total immersion for a period of 48 hours in a 4M NaCl + 0.5M KNO_3 + 0.1M HNO_3 solution. In addition, selected lots of the sheet, plate and extruded products were exposed to the acidified salt spray test such as specified in MIL-A-8978, 8979 and 8980 for 7178-T76 products[27], and to the seacoast atmosphere at Point Judith, Rhode Island. Specimens exposed to the two accelerated tests were rated visually using the photographic standards contained in ASTM G34[26], Fig. 45.

C.2. Resistance to Stress-Corrosion Cracking (SCC)-Smooth Specimens

Sheet

Stress-corrosion cracking tests were conducted with two types of long-transverse specimens: a premachined tensile specimen (ASTM E8, Fig. 8), and a plastically deformed tensile specimen blank. Full thickness specimens were used for 0.040 and 0.063-in. sheet; for thicknesses greater than 0.063 in., specimens were machined on one surface to 0.063 in. and the original rolled surface was stressed in tension. Both types of specimens were stressed in duplicate, by bending in constant span-type fixtures, Fig. 46, with the tensile specimens being end-milled to a length calculated to develop a stress of 75 per cent of the measured tensile yield strength. Duplicate unstressed tensile specimens were also exposed.

Specimens were exposed to three environments: (a) 3.5 per cent NaCl by alternate immersion per Federal Test Standard 151b, Method 823[28]; (b) seacoast atmosphere at Point Judith, Rhode Island; and (c) industrial atmosphere at Alcoa Center, Pennsylvania. Atmospheric tests are scheduled for a minimum exposure of four years, but at the time this report was written, the maximum length of accrued exposure was only about 22 months.

Plate, Forgings and Extrusions

The resistance to stress-corrosion cracking of susceptible aluminum alloys and tempers is most critical in the short-transverse direction (perpendicular to and across the parting plane in the case of die forgings); consequently, the majority of tests were made on specimens oriented in that direction. Certain items were also tested in the longitudinal and long-transverse directions.

Tests were conducted with 0.125-in. diameter threaded end tensile specimens meeting the requirements of ASTM E8. Specimens were centered in the product thickness, except that for die forgings the short-transverse specimens were taken across the parting plane approximately 3/8-in. below the base of the flash.

Unstressed specimens were exposed in duplicate and stressed specimens in triplicate. All specimens were axially loaded in tension in "constant strain" type fixtures, Fig. 47a, using a synchronous loading device of the type shown in Fig. 47b. Longitudinal and long-transverse specimens were stressed at 75 per cent of the actual tensile yield strength, and short-transverse specimens were stressed at 45, 35 and 25 ksi.

The corrosive environments used were the same as those cited in the preceding section for sheet samples. Atmospheric tests of these samples had progressed for approximately 20 to 25 months at the time this report was written.

C.3. Resistance to SCC - Precracked Specimens

Stress-corrosion cracking tests of precracked specimens were conducted on plate, die forged and extruded samples with bolt-loaded double cantilever beam (DCB) specimens of the types shown in Fig. 48. Short-transverse specimens of S-L orientation were taken from the plate and extruded sections at the center of the product thickness, and specimens from the die forgings were taken just below the parting plane as shown in Fig. 49.

Duplicate specimens were precracked in tension, with a few drops of a 3.5 per cent NaCl solution being applied during the final stage of precracking. The specimens were then held for a period of 30 days in a laboratory environment with air at 80 F and 45 per cent relative humidity. A few drops of a 3.5 per cent NaCl solution were added to the crack three times during each working day, and crack growth was monitored with an ultrasonic detection device developed at these Laboratories. Pertinent stress-intensity calculations, as a function of crack opening displacement and crack length, were made using the formula developed by Hyatt[29].

SECTION IV

RESULTS OF TESTS

The results of the individual tensile, compressive, shear and bearing tests, the ratios among these test results, the statistical analyses of these ratios, the computed design values and the modulus of elasticity data are shown in Tables II through XXVIII. Tensile and compressive stress-strain curves for samples of five lots of each product are shown in Figs. 50 through 83.

The results of the tests of the 16-in. wide center-slotted panels (K_c) and the compact tension fracture toughness specimens (K_{Ic}) are shown in Tables XXIX through XXXIII and Figs. 84 through 93.

The results of the smooth and notched axial-stress fatigue tests, ambient-air environment, and modified Goodman diagrams are shown in Figs. 94 through 140; those of the smooth and notched specimens tested in a salt-fog environment are presented in Figs. 141 through 145. Either scatter bands or average curves are shown representing results of tests of comparable products of other aircraft alloys[12]. Table XXXIV lists the average corrosion-fatigue strengths at several lives for these tests, as well as those for comparable products[12].

The results of the fatigue crack-growth tests are presented in the form of da/dN versus ΔK plots in Figs. 146 through 160 and summarized in Table XXXV. The table includes rates listed for some of the tests of comparable specimens and products[12]. The raw crack-propagation data are presented in the Appendix (Tables LIV to LVII).

The results of the exfoliation tests are given in Tables XXXVI through XXXIX and Fig. 161. The results of accelerated and atmospheric stress-corrosion tests of smooth specimens are shown in Tables XL through L and Figs. 162 through 166. Results of tests of precracked specimens are shown in Tables LI through LIV and Figs. 167 through 172.

SECTION V

DISCUSSION OF RESULTS

GENERAL

The results of tests obtained in this investigation of the mechanical properties and corrosion characteristics of 7050 products provide evidence that this alloy is capable of developing the combination of high strength, high resistance to corrosion, and a high level of fracture toughness not available previously in other commercially produced aluminum alloy products. The data generally confirm that 7050 products produced by commercial practices develop the yield strength-corrosion resistance combination estimated from alloy development data. These properties, the development of design mechanical properties, the fracture toughness, and the fatigue characteristics are discussed in detail in the following sections.

A. Mechanical Properties

A.1. Tensile, Compressive, Shear and Bearing

A.1.1. Minimum and Maximum Tensile Properties

The methods used in establishing minimum and maximum tensile properties were discussed in Section I. The minimum tensile yield strengths for the various products appear reasonable with the possible exception that for certain extruded shapes it may be necessary to lower either the maximum and minimum strengths or the stress-corrosion capability based on stress-corrosion data for the 1.5x7.5-in. and similar shapes; this is discussed in detail in C2 of this section.

Analysis of subsequent tensile and stress-corrosion test results of plate and hand forgings tested for this contract and for quality control purposes indicated that the 9 ksi spread between minimum and maximum yield strengths was unnecessarily restrictive for thick sections. The stress-corrosion resistance of the thicker sections is such that higher maximum yield strengths can be tolerated. Consequently, the maximum yield strengths for 3.001 in. and thicker sections have been revised to 9 ksi higher than the minimum values of 3-in. thick plate and hand forgings.

As mentioned in Section I, the minimum tensile ultimate strengths of the 7050 products were estimated from the relationships of yield strength to ultimate strength for established commercial 7XXX alloy products. These relationships for the data obtained in this contract indicate that it may be necessary to adjust some

of the minimum tensile ultimate strengths. However, the amount of data obtained in this contract are not sufficient to justify such revisions; further supporting data from production lots are necessary before revisions can be made with any degree of confidence. For changes to be made in the minimum values for plate, hand forgings and die forgings, it would be necessary to revise AMS specifications. In the case of 7050-T73651 plate the yield-ultimate relationships for data from this contract and other plant production indicate revisions in the tensile ultimate strengths may not be necessary.

A.1.2. Design Mechanical Properties

The tensile properties used in computing the ratios among the tensile, compressive, shear and bearing properties for each product meet applicable specified minimum properties except those for some of the hand forgings and die forgings fabricated by Producer B, as noted in Section II, Materials; the ratios are shown in Tables VIII through XII.

The distribution of the ratios, number of ratios (n), mean ratios ($\bar{R}$), standard deviations ($\sigma_{\bar{R}}$) and the minimum ratios (Min. $\bar{R}$) are shown in Tables XIII through XVII. The statistical analyses of the ratio data were made in accordance with procedures outlined in Chapter 9 of MIL-HDBK-5, Guidelines for Presentation of Data[5]. A regression analysis of each group of ratios was made to determine whether the data showed a correlation with thickness; where such correlation was indicated, Min. $\bar{R}$ values were selected which correspond with the lower limit of the confidence band around the regression line at the lower end of each respective thickness range. When no correlation was indicated, a single value of Min. $\bar{R}$ was selected for all thicknesses. These values of Min. $\bar{R}$ were used to establish the derived design value for the respective thickness ranges. In some instances variation in the ratios throughout the full thickness range indicated that the ratios should be broken down into sub-groups for analysis. This was done with the analysis of the bearing data for sheet, i.e., the ratios for 0.040 and 0.063-in. thick sheet and those for thicknesses greater than 0.063 in. were analyzed separately. The analyses of the shear and bearing ratios for plate were made on thicknesses equal to or less than 1.500 in. and greater than 1.500 in. The ratios for these two thickness ranges differ because of the change in the specification-test location, T/2 to T/4. This was not recognized in the previous Air Force Contract on 2014-T651, 2024-T351 and -T851, 7075-T651 and 7178-T651 plate[7]. Consequently, the Min. $\bar{R}$ values used to develop derived minimum values presently shown in MIL-HDBK-5B, insofar as the approach to the analyses are concerned, are not comparable to those for 2124-T851[12], 7075-T7351[30] and 7050-T73651 plate.

Since no directions are shown for shear and bearing minimum design values and data were obtained for more than one direction in most products, the Students "t"-test and the "F"-test were applied to determine if there were significant differences in $\bar{R}$ or $(\sigma\bar{R})^2$, respectively, for the different directions. Where no differences with direction were indicated, the ratios were combined for computation of the minimum ratios. The approach taken in combining ratios was to average the individual ratios for the two directions of each sample and then run the statistical analysis on the average ratios. By using this approach, the analysis was based on the number of samples (lots) tested and not the number of tests thus keeping "n" equal, or about equal, for each property of each product.

The derived Min. $\bar{R}$ values used in computing the derived design values from the tensile properties of the respective thickness ranges of each product are summarized in Tables XVIII through XXI. The corresponding computed design values are shown in Tables XXII through XXVI. In preparing the design tables for the plate, hand forgings and die forgings the tensile properties in AMS specification 4050, 4108 and 4107, respectively, were used as basis-property "S" values. Since there are no such specifications for 7050 sheet and extruded shapes, Alcoa's tentative minimum tensile properties were used; therefore the design properties are shown as "tentative" in Tables XXII and XXVI. With the exception of extruded shapes, the derived compressive values for each direction are based on the corresponding directions of the tensile yield strengths. There are presently no long-transverse specified minimum tensile properties for extruded shapes, so all derived values are based on the longitudinal tensile properties. The shear and bearing minimum values for sheet, plate and hand forgings are based on the long-transverse tensile properties and for die forgings they are based on the longitudinal tensile properties.

The results of the tensile and compressive stress-strain tests and the modulus of elasticity tests are summarized in Table XXVII. Representative tensile stress-strain plots for determining modulus of elasticity from zero to 25 ksi are shown in Fig. 50, and tensile and compressive stress-strain curves are shown in Figs. 51 to 83. Average modulus values (Table XXVIII) for each product are as follows:

		Modulus, 10^3 ksi(0 to 25 ksi)	
Product	Temper	Tension	Compression
Sheet	T76	10.2	10.5
Plate	T73651	10.3	10.5
Hand Forgings	T73652	10.2	10.5
Die Forgings	T736	10.2	10.5
Extruded Shapes	T76511	10.3	10.6

The above values for the 7050 products are generally within 2 per cent of those of other 7XXX alloys. These average values for each product are, as with other alloys, 2 to 3 per cent higher in compression than in tension.

The long-transverse modulus values for plate, hand forgings and extruded shapes average 1 to 2 per cent higher than the corresponding longitudinal values; for the same products the short-transverse modulus values average 1 to 2 per cent lower than the long-transverse values. The longitudinal and long-transverse modulus values for sheet average about the same and for die forgings the longitudinal and short-transverse modulus values are about equal.

The proportional limit in tension is usually not much above 25 ksi for most 7XXX products, and in compression the proportional limit is appreciably higher than that in tension. Therefore, in the tests of 7050, the modulus tests in compression were run to only 25 ksi so that the stress range evaluated was the same as that in tension. However, most of the compressive stress-strain curves for 7050 showed that above 25 ksi the slope (modulus) increased noticeably up to the elastic limit. The amount of this change in slope appears to vary with grain direction and with product. However, this change in slope is directly related to the elastic limit of the product, the higher the elastic limit the greater the change in slope (modulus). In the longitudinal direction of hand forgings there is little or no increase in slope as the stress increased within the elastic range, but in the transverse directions (LT and ST) of the hand forgings and all three directions of plate, the slopes of the upper part of the elastic range average 2 per cent higher than those of the lower part (0 to 25 ksi). For sheet, die forgings and extruded shapes the differences in the slopes average about 2.5 to 3.5 per cent for the longitudinal direction and 4 to 4.5 per cent for the two transverse directions. This increase in slope is not unique for 7050; it has been observed in data for other high-strength alloys. The compressive modulus values have been adjusted upward as shown in Table XXVIII; these values are based on a stress range of zero to the elastic limit. The modulus values in the tables of design mechanical properties (Tables XXII through XXVI) have been adjusted accordingly.

A.2. Fracture Toughness

Sheet

The results of the tests of 16-in. wide center-slot fracture toughness specimens of the 7050-T76 sheet are shown in Table XXIX. On the basis of the net section stress, σ, not exceeding 0.8 times the tensile yield strength, all tests were valid.

Values of K_c versus tensile yield strength for the 0.063-in. 7050-T76 sheet are plotted in Fig. 84; data for other alloys of sheet tested without anti-buckling guides are shown for comparison. One sample of 7050-T76 sheet (411378) has yield strengths, averaging about 78 ksi, greater than and K_c values equivalent to those of 7075-T6. The second sample of 7050 (428884), has yield strengths, averaging 73 ksi, in the range of those of 7075-T6 and 7475-T61; for the L-T orientation the K_c values, with and without anti-buckling guides, are equal to or higher than those of 7475, and for the T-L orientation they are between those of 7075-T6 and 7475-T61. The larger differences in the K_c values of the two samples of 7050-T76 sheet appear to be a trade off in yield strength and toughness which is, at least partially, due to differences in Cu and Zn content (Table I).

Values of K_c versus thickness are plotted in Fig. 85 for specimens with initial slot-lengths of 4-in. The K_c values of the thick sheet average about 2/3 those of the thin sheet.

Crack-resistance data for the two samples of 0.063 in. sheet (S-411378 and 428884), tested with anti-buckling guides, (open symbols), are shown in Figs. 86 and 87 for the L-T and T-L orientations, respectively. These data characterize the resistance to fracture of the sheet during slow-crack growth. The R-curves for the two samples of sheet indicate large differences in their resistance to fracture, which can be partially attributed to the differences in the tensile yield strengths of the two samples.

The function of the anti-buckling guides in the fracture toughness tests of sheet was to prevent buckling. Buckling can lower not only the toughness, K_c, but also the resistance to slow-crack growth as demonstrated by the data for the L-T and T-L orientations (4 and 6-in. crack lengths) of the 0.063-in. sheet (S-428884) in Figs. 86 and 87, respectively.

The method recommended by C. E. Feddersen[22] for analyzing residual strength was used to establish various "damage" levels, K, from load-deformation curves obtained from tests of the 16-in. wide panels of 0.063-in. thick sheet (S-411378). The results of the evaluations of the data, assuming panels of infinite width, are presented in Figs. 88 (L-T) and 89 (T-L); the three damage levels established are: 1. "Threshold"-beginning of slow-crack growth, 2. "Apparent"-no crack growth at critical instability, and 3. "Critical"-initial crack length plus crack growth at critical instability. The data for the 0.063-in. sheet appear to fit Feddersen's analyses reasonably well, at least in the fracture-mechanics applicable range.

Plate, Hand Forgings, Die Forgings and Extruded Shapes

The results of the fracture toughness tests, K_{Ic}, are shown in Tables XXX through XXXIII. Only a few of the candidate K_Q values for plate and hand forgings are not strictly valid by all the criteria stipulated in ASTM E399. However, as indicated in the tables, most of these values are considered meaningful K_{Ic} values since they almost satisfy the validity criteria. Most of the K_{Ic} values for die forgings are invalid primarily because either the crack lengths were outisde limits, crack curvatures exceeded limits or the stress intensities were too high. At times it was difficult to initiate and propagate the fatigue cracks in the die forging specimens, which accounts for the relatively high stress intensity and crack curvature. Almost one-third of the K_{Ic} values for extruded shapes were strictly invalid; most of the invalid tests were for the L-T specimens and were due to excessive yielding. Average values of valid K_{Ic}, including values considered meaningful, are as follows:

		K_{Ic}, ksi $\sqrt{in.}$		
Product	Temper	L-T (L-S)	T-L	S-L
Plate	T73651	32.2	27.8	24.2
Hand Forgings	T73652	31.9	20.9	19.0
Die Forgings	T736	31.9(37.7)	--	23.7
Extruded Shapes	T76511	31.6	23.0	18.6

K_{Ic} values versus tensile yield strengths of plate, hand forgings, die forgings and extruded shapes are plotted in Figs. 90 through 93, respectively. Both valid (solid symbols) and invalid (open symbols) fracture toughness data are shown. Generally, in Figs. 90, 91 and 93, bands are shown for conventional alloys which include data for 2014, 2024, 2219, 2618, 7075, 7079 and 7178[30]; data for 7049[12] and 7175[12] hand forgings are also represented in Fig. 91. Data for other die forgings in Fig. 92 are limited to 7075[30], 7049[12] and 7175[12]. Comparisons of 7050 with these other alloys are as follows:

Plate (Fig. 90): Generally, the K_{Ic} values for the 7050-T73651 are higher than those of conventional alloys of comparable yield strengths and thickness. The two data points (circles) within the band for the L-T orientation and the two data points (squares) within the band for the T-L orientation represent 6-in. plate while the bands for conventional alloys represent thinner plate. For the S-L orientation (triangles) all six samples of plate have K_{Ic} values above the band.

Hand Forgings (Fig. 91): The combination of toughness and strength for 7050-T73652 in the L-T orientation are about comparable to those of 7175-T736 and better than those of 7049-T73 and other conventional alloys. For the T-L and S-L orientations the combination of toughness and strength are in the same range as those of 7049-T73 and the conventional alloys, and a little lower than those of 7175-T736. The overall sizes of the 7050 forgings are generally larger than those of the other alloys.

Die Forgings (Fig. 92): The data for the L-T and S-L orientations of 7050-T736 are comparable to those of 7175 and 7049, but for the L-S orientation 7050 exhibits a higher strength-toughness combination than 7175 and 7049.

Extruded Shapes (Fig. 93): The toughness of 7050-T76511 is comparable to that of the conventional alloys while maintaining yield strengths at the higher-strength end of the range of conventional alloys.

A.3. Axial-Stress Fatigue

A.3.1. Ambient-Air Environment

The results of the axial-stress fatigue tests of smooth and notched (K_t=3) specimens are shown in Figs. 94 through 128. Curves have been drawn through data points for one sample each of sheet, plate, hand forgings and extruded shapes for stress ratios of +0.5, 0.0 and -1.0. For the purpose of establishing modified Goodman diagrams (Figs. 129 through 140) for these samples, the curves were adjusted slightly from those drawn through the points.

Comparisons of the fatigue data for 7050 products with curves or bands for sheet of other 7XXX alloys are as follows:

Sheet - Smooth and Notched Specimens (Figs. 97 and 101): 7050-T76 fatigue strengths are in the same range as those of single lots of 7075-T6, -T76 and -T73 sheet[30].

Plate - Smooth Specimens (Fig. 105 and 106): The band shown in Fig. 105 is for 1-1/4 to 1-3/4-in. thick 7075-T7351 plate[30]. Data for one of the samples of 1-in. thick 7050-T73651 plate (●,○) fall a little below this band between 10^4 and 10^6 cycles, but the fatigue limits at 10^7 cycles fall just within the band. The data for the other sample of 1-in. thick plate (■,□) generally fall in the lower half of the band. For the 2-in. thick plate (▲,△) the data fall near the center of the band. No direct comparison can be made for the 4 and 6-in. plate, but their fatigue strengths are about as expected for their relatively large thicknesses. The data for the 1-in. and 2-in. 7050 plate and the data for the 1-1/4 to 1-3/4-in. plate from which the band was established for the 7075-T7351 plate are plotted in Fig. 106; also shown is the band for 7075-T73XXX products[30]. The fatigue strengths for the 2-in. 7050 plate are comparable to that of the 1-3/4-in. 7075-T7351 plate.

Plate - Notched Specimens (Fig. 110): The fatigue strengths of 7050-T73651 are within or above the band for 7075-T73XXX products[30]. The long-transverse strengths of the 7050 plate are generally higher than those for the longitudinal direction and, beyond 10^5 cycles, are equal to or higher than those for one lot of 7075-T7351 plate.

Hand Forgings - Smooth Specimens (Fig. 113): The longitudinal fatigue strengths of the 4-1/2x22x84-in. 7050-T73652 forging fall in the center and the long-transverse strengths for all five forgings fall in the lower half of the band for 7075-T73XXX products. The strengths are lower than the strengths of smaller sizes of 7175-T736 hand forgings[12], but appear to be about the same as those for 7049-T73 hand forgings[12].

Hand Forgings - Notched Specimens (Fig. 116): The data for 7050-T73652 forgings fall within or above the band for 7075-T73XXX products[30]. The strengths are in about the same range as those of 7049-T73 hand forgings[12] and a little lower than the strengths of 7175-T736 hand forgings[12].

Die Forgings - Smooth and Notched Specimens (Figs. 118 and 120): The fatigue strengths of 7050-T736 are comparable to those of 7075-T73[30], 7049-T73[12] and 7175-T736[12] die forgings.

Extruded Shapes - Smooth Specimens (Fig. 124): The fatigue strengths of 7050-T76511 shapes are about the same as those of 1.25 to 2.00-in. 7075-T7651X shapes[30]. As would be expected, the long-transverse strengths of the 3.5 and 5-in. thick shapes are lower than those of the thinner 7050 shapes; the longitudinal strengths, however, are higher than those of the thinner shapes.

Extruded Shapes - Notched Specimens (Fig. 128): The fatigue strengths of the 7050-T76511 shapes average a few ksi lower than those of the 1.43 and 2.0-in. 7075-T7651X shapes.

A study of the chemistry, fabrication practices and testing conditions has been made in an effort to explain the low fatigue strengths for the smooth specimens of the two samples of 1-in. plate (411050 and 411185) relative to the strengths of the 2-in. plate (411186). The only conclusions that could be made concerning the strength of sample 411185 was that this plate had a more recrystallized grain structure than that of the 2-in. plate. Limited evidence suggests that an unrecrystallized grain structure will be more resistant to fatigue damage than a recrystallized structure. As for the other sample of 1-in. plate (411050), which was unrecrystallized and has the lowest fatigue strengths,

the humidity at the time of testing may have been a factor; the humidity was higher when testing this sample as compared to that when the other two samples were tested. Values up to 105 grains of H_2O per pound of dry air were estimated. The same lot of 1-in. plate was tested by independent investigators where the absolute humidity values were in a range from 20 to 40 grains per pound[31]. Their results, adjusted from 0.1 to 0.0 stress ratio, were as much as 7 ksi higher than the 2-in. plate and at least 10 ksi higher than the corresponding sample of 1-in. plate (411050). These differences in strength appear too high to be attributed to differences in humidity alone; other variables such as test specimens and equipment probably contributed to the differences in fatigue properties obtained from the same lot.

A.3.2. Salt-Fog Environment

As is common in corrosion-fatigue tests, the salt-fog environment lowers the fatigue strength of all products (Table XXXIV and Figs. 141 to 145) with the effect of environment being greatest at the lower stresses where the exposure is longest and the effect of a notch is greatest. For the smooth specimens the failures of the specimens lasting more than a day (1,580,000 cycles) had their origins in corroded areas, and the lives were within the scatter band for mildly notched specimens, $K_t=3$ tested in air. The number of corrosion-fatigue tests was small, but the following trends can be noted for the various products:

7050-T76 Sheet - Smooth and Notched, $K_t=3$, Specimens (Fig. 141):

The 0.040-in. thick unnotched specimens have longer lives than the 0.125-in. thick specimens. This is in variance with the thought that comparable pits should have more effect on the thinner sheet, which was the finding for the 7475-T761 sheet[12]. The lives of notched specimens of the two sheet thicknesses are equivalent. For medium lives the fatigue results for the smooth and notched 7050-T76 specimens approximate the average curves for the 0.040-in. 7475-T761 sheet[12]. However, beyond 10^6 cycles, the 7050 specimens are affected by the environment to a greater degree.

7050-T73651 Plate - Smooth and Notched, $K_t=12$, Specimens (Fig. 142):

The corrosion-fatigue strengths of the two thicknesses of plate were equivalent. For smooth specimens of the 7050-T73651 plate, the fatigue strengths were in the same range as those of 2124-T851 plate[12] for lives up to 10^6 cycles. For notched specimens the strengths were below those of 2124-T851 plate.

7050-T73652 Hand Forgings - Smooth and Notched, K_t=12, Specimens (Fig. 143): No variations of corrosion-fatigue strengths with forging size were noted. The long-life fatigue strengths for the smooth 7050 specimens were lower than the average curves obtained in a previous test program for 7049-T73 and 7175-T736 hand forgings[12]. Similarly, the long-life data for the sharp-notched 7050 specimens were three to four ksi below the curve for 7049-T73 specimens.

7050-T76511 Extruded Shapes - Smooth and Notched, K_t=12, Specimens (Fig. 144): The corrosion fatigue lives for smooth and notched specimens of the 1.161 in. thick extruded shape were generally longer than those from 3.5x7.5-in. extruded bar.

Comparison of Products

Average curves representing the results of the tests of two sizes each of plate, forgings and extruded products are shown in Fig. 145 and summarized in Table XXXIV. Comparison with the fatigue strengths of the sheet would not be valid because of the different specimen types. The curves for the smooth specimens have somewhat different shapes but appear equivalent. However, for the notched specimens, the curve for the 7050-T73651 plate is consistently 1 to 2 ksi lower than those for the hand forgings and extruded shapes.

The failures of the smooth specimens which had lives greater than 1,000,000 cycles generally were directly related to corrosion. In most cases a corrosion pit served as the origin. However, the failure of one 0.125-in. sheet specimen started in an area of intergranular attack. There was no evidence of stress-corrosion attack.

B. Fatigue Crack-Propagation Tests

Some of the plots of crack-propagation rates show substantial scatter and overlap. Accordingly, differences in fatigue crack-growth rates of less than 50 per cent, in the summary Table XXXV, are not considered significant. There is generally good agreement between the da/dN-ΔK relationships for tests made at either low or high stress levels, with an overlapping ΔK range. The effects of orientation and environments are discussed below for the various products.

7050-T76 Sheet (Figs. 146 to 148):

a. At the lower stress intensities the rates of fatigue crack propagation for T-L specimens of the 0.040 and 0.125-in. sheet were comparable in each atmosphere (Figs. 146 and 147). However, propagation at the higher stress intensities is somewhat slower in the thinner sheet.

b. Equivalent propagation rates were obtained for T-L and L-T specimens (Figs. 147 and 148).

c. The humid air doubles the rate of crack propagation over that of dry air. At the low stress intensities, propagation in the salt-fog environment is 50% faster than in humid air, but at the higher stress intensities equivalent propagation is obtained in the moist environments.

d. The rates of propagation are comparable to those reported for 7475-T61 and T761 sheet (T-L specimens).

<u>7050-T73651 Plate (Figs. 149 to 152)</u>:

a. The rates of fatigue-crack propagation for T-L specimens of the 1-in. and 6-in. plate are comparable in each atmosphere (Figs. 149 and 150).

b. The rates of propagation for the 6-in. plate (Figs. 150 to 152) do not differ greatly with specimen orientation.

c. At the lower stress intensities, the rates of propagation in salt fog are about triple and those in humid air are about double those in dry air. At the higher stress intensity range of 12 ksi $\sqrt{in}$. listed in Table XXXV, the rates in the two moist environments are both about double those in dry air.

d. At the lower stress intensities, propagation rates of the 7050-T73651 specimens are slower than those reported for 2124-T851 plate in dry and humid air, but the rates are equivalent at the higher stress intensities (T-L specimens).

<u>7050-T73652 Hand Forgings (Figs. 153 to 156)</u>:

a. Crack propagation is generally faster for T-L specimens from the 7-1/2-in. thick forgings (Fig. 154) than for similar specimens from the 2-1/2-in. thick forgings (Fig. 153).

b. For the 7-1/2-in. forgings at the higher stress intensities, the rates of propagation are faster for T-L and S-L specimens than for L-T specimens (Figs. 154, 156 and 155). Propagation is particularly fast for the S-L specimens at the higher stress intensities. The disparity between the resistance to crack propagation in the T-L and L-T specimens was such that the cracks of specimens LT-1 and LT-2 changed to vertical (longitudinal) propagation at a/W values of 0.55 to 0.60. Near the transition, propagation at midthickness lagged behind surface measurements rather than leading them as is

normal for specimens of this thickness. Accordingly, the width, W, of the remaining L-T specimens was reduced to produce specimens having an H/W ratio of 0.60 instead of 0.485. Comparison of the rates of propagation in Fig. 155 shows similar performance for Specimens LT-2 and LT-5 having the two H/W ratios. The rate of propagation showed a slower rate of increase as ΔK increases beyond 10 ksi $\sqrt{in}$. for any of the longitudinal specimens.

c. The salt-fog environment generally increases the rates of propagation significantly over those obtained in humid air, which are, in turn, 50 to 100 per cent faster than those obtained in dry air.

d. At the higher stress intensities, propagation is faster (T-L specimens) for the 7050-T73652 forging than for the 7175-T736 forging and is comparable to 7049-T73. At low stress intensities the rates for both 7050-T73652 and 7175-T736 forgings are slower than those of 7049-T73[12].

<u>7050-T76511 Extruded Shapes (Figs. 157 to 160)</u>:

a. For the thinner shapes equivalent propagation is obtained in the longitudinal and long-transverse directions in the humid environments although, in dry air, propagation is somewhat slower for L-T than for T-L specimens (Figs. 157 and 158).

b. At the higher stress intensities, the L-T specimens from the thick shapes (Fig. 159) experienced a slowing of propagation similar to that shown for the L-T specimens from the thick hand forging (Fig. 155). For those specimens having H/W = 0.485, vertical (longitudinal) propagation resulted. The data for the thinner extruded shape (Fig. 158) did not show any such trend so the rates for L-T specimens from the thinner shape are significantly faster at the higher stress intensities.

c. Propagation is particularly fast for the S-L specimens (Fig. 160) at the higher stress intensities.

d. The moist environments increased the propagation at lower ΔK by factors of 3 or more.

<u>Comparison of Products</u>

a. In the thick extruded shapes and hand forgings, propagation at the higher stress intensities occurs significantly faster in the longitudinal direction than transverse directions; propagation is particularly fast for the S-L specimens. No such behavior was found for the plate.

b. Generally, similar crack-propagation behavior is obtained from T-L specimens of the thinner products of the plate, hand forgings and extrusion.

c. Except at the high stress intensities, propagation of all products in humid air and in salt fog is faster than in dry air by factors of about two and three, respectively.

C. Corrosion Characteristics

C.1. Resistance to Exfoliation

All products showed a high resistance to exfoliation in the "EXCO" immersion test. Specimens from the T736 die forgings showed no exfoliation, but minor exfoliation was detected on nearly all samples of T76 sheet, T73651 plate, T76511 extrusions and T73652 hand forgings, and these samples were rated in the E-A category, Fig. 45. One sample of T76 temper sheet was rated E-B. Fig. 161 illustrates the minor nature of the exfoliation attack in representative samples from the extruded and plate products.

Acidified salt spray tests also developed minor exfoliation of the degree E-A on selected samples of the extruded shapes and hand forgings, but no exfoliation was observed on the sheet and plate samples.

The development of minor exfoliation (degree E-A) for these materials in these aggressive accelerated test media is believed to be of no practical importance because it has been shown by outdoor tests in a seacoast atmosphere to be of little practical significance for similar products of 7075 and 7178 alloys[32,33]. It is expected that it will be shown to be equally insignificant for alloy 7050 products with the attainment of more lengthy atmospheric exposure.

At the time this report was prepared, tests of selected samples of sheet, plate and extruded shapes had progressed for a period of 23 months in the seacoast atmosphere at Point Judith, Rhode Island, with no evidence of exfoliation attack.

C.2. Resistance to Stress-Corrosion Cracking (SCC)-Smooth Specimens

Sheet (Tables XL and XLV): The sheet exhibited excellent resistance to SCC in the long-transverse direction for all thicknesses tested. No failures occurred in the accelerated tests even with the highly-stressed preformed specimens. The sheet has been equally resistant in both seacoast and industrial atmospheric tests of 606 and 660 days duration.

Plate (Tables XLI and XLVI): Longitudinal and long-transverse specimens showed good resistance to SCC. Long-time failures (101-182 days) did occur with specimens of either orientation, but microscopic examination revealed deep surface pitting and transgranular auxiliary cracking. Fig. 162, not typical of SCC.

Short-transverse specimens also showed a high resistance to SCC. No failures occurred at test stresses of 45, 35 and 25 ksi during the first 30 days of exposure, which is the period commonly used for SCC evaluations of high-strength aluminum alloys. Specimens stressed at 45 and 35 ksi did fail with continued exposure, and metallographic examination revealed pitting plus a mixture of intergranular, transgranular and mixed mode auxiliary cracking. It was concluded that fracture resulted primarily from intergranular SCC (Fig. 163).

No failures have occurred with short-transverse specimens stressed at 45, 35 and 25 ksi during exposures of 730 days in the seacoast atmosphere and 763 days in the industrial atmosphere.

Hand Forgings (Tables XLII and XLVII): Longitudinal and long-transverse specimens from hand forgings were also resistant to SCC. Failures which did occur were again associated with severe pitting and transgranular cracking not typical of SCC.

Short-transverse specimens showed a similar high resistance to SCC. No failures occurred during the first 30 days of exposure at stresses of 45, 35 and 25 ksi. Failures did occur at both 45 and 35 ksi with longer exposure, but microscopic examination of representative specimens revealed deep surface pitting and predominantly transgranular auxiliary cracking, (Fig. 164) not typical of SCC.

In seacoast atmospheric tests of 605 days duration, specimens from two of the five forgings tested have failed at a stress of 45 ksi. A single specimen has also failed at 25 ksi. Microscopic examination of these specimens showed that they resulted from severe localized corrosion and were not typical of SCC. No failures have occurred in industrial atmospheric tests of 665 days duration.

Die Forgings (Tables XLIII and XLVIII): Tests of a limited number of specimens confirmed the expected high resistance to SCC in the longitudinal direction. Failures did occur after long periods of exposure (124-182 days), but they too were not typical of SCC. No long-transverse specimens were tested.

Short-transverse specimens from the 7050-T736 die forgings showed some susceptibility to SCC in the alternate immersion test. Specimens from two of the ten forgings tested failed in 30 days or less at a stress of 45 ksi, but no failures occurred at stresses of 35 and 25 ksi during that period. With longer exposure most specimens failed at 45 ksi; numerous specimens failed at 35 ksi and two specimens failed at 25 ksi. Microscopic examination of representative test failures revealed a predominantly interfragmentary mode of auxiliary cracking indicative of SCC, Fig. 165.

After 605 days of exposure, tests in the seacoast atmosphere showed the same trends observed in the accelerated tests. SCC failures had occurred at 45 and 35 ksi with specimens from four of the ten forgings tested. In industrial atmospheric tests of 605 - 673 days duration, a single failure occurred at 45 ksi. Interfragmentary nature of auxiliary cracking in these atmospheric test failures is also shown in Fig. 165.

Extruded Shapes (Tables XLIV and XLIX): Longitudinal and long-transverse specimens showed a high resistance to SCC similar to the other products.

The short-transverse SCC performance of 7050-T76511 extruded shapes was expected to be similar to that of 7075-T76511 sections which are required to pass a 30 day test at 25 ksi. The shapes tested, with the exception of the 1.5x7.5-in. rectangular bar, performed as expected.

Short-transverse specimens from the 1.5x7.5-in. bar failed at a stress of 25 ksi in 30 days or less, and during longer exposure failures occurred at a stress of 20 ksi. The performance of this shape has also been shown to be substantially below that of other 7050 shapes in other test programs, and the results of one investigation[34] showed that this shape would have to be overaged to lower strengths than other 7050 shapes to develop the same resistance to SCC. Therefore, portions of the 1.5x 7.5-in. bar were given additional aging at 325 F, and tests of short-transverse specimens from these re-aged samples showed that the material aged five additional hours at 325 F (20 hours total) demonstrated the expected resistance to SCC with only a slightly lowering of the mechanical properties. Pertinent data for this re-aged bar are listed below:

E.C.	Longitudinal Properties			Applied Stress,	SCC Data	
%IIACS	TS ksi	YS ksi	El. %	ksi	F/N	Days
40.5	83.7	77.0	13.6	55	3/3	5, 33, 34
				25	1/3	71, 2 OK 84

In seacoast atmospheric tests of 680 days duration, short-transverse specimens have shown the same trends observed in accelerated tests. SCC failures occurred at 45 and 35 ksi with each of the four sections tested, and two of the four sections failed at 25 ksi. No failures have occurred in industrial atmospheric tests of 721 days duration.

The interfragmentary character of auxiliary cracking in representative SCC test failures is shown in Fig. 166.

Summary of Exfoliation Tests and SCC Tests of Smooth Specimens

The corrosion performance of the various 7050 alloy products tested under this contract is compared with proposed corrosion targets in Table L.

In general, the various products showed the expected resistance both to exfoliation corrosion and stress-corrosion cracking. The lone exception was that the exfoliation resistance of 7050-T73651 plate was slightly less than that of 7075-T7351 plate, but the level of exfoliation in these plate samples was only of a degree E-A (ASTM G34-72), and is not considered significant.

The SCC performance of the 1.5x7.5-in. 7050-T76511 extruded shape indicated a need for a modified aging practice for sections of this type. Such modifications may result in revision of the tentative strength requirements; additional studies are currently being made under an extension of AFML Contract No. F33615-73-C-5015.

The resistance to general corrosion of these 7050 products in the highly aggressive 3.5 per cent NaCl alternate immersion environments is reflected by the reduction in tensile strength data for unstressed specimens in Tables XL through XLIV. A comparison of the 7050 hand forging data with those for similar forgings tested in a prior investigation[7] indicates that 7050 alloy is slightly less resistant to general corrosion in saline environments than other 7XXX alloys such as 7175 and 7049. The reduction in tensile strength for unstressed short-transverse specimens exposed 84 days to the 3.5 per cent NaCl alternate immersion test were as follows: 7175-T736, 14-24 per cent; 7049-T73, 24-32 per cent and 7050-T73652, 32-40 per cent. The reductions for 7050-T73651 plate approached, but were lower on the average than losses for short-transverse specimens of similar thickness plate of 2124-T851: 7050-T73651, 29-38 per cent; 2124-T851, 32-45 per cent. These data show the relative performance of small diameter specimens in a highly corrosive environment and cannot be directly related to the structural damage that might be expected with larger sections in service environments.

Stressed tension specimens that survived the 84 or 182 day alternated immersion exposure to the 3.5 per cent NaCl solution typically showed higher reductions in tensile strength than the unstressed specimens, particularly at high levels of applied stress (this was true also for the 7175-T736 and 7049-T73 forgings and for the other 7050 alloys products). A prior investigation of accelerated SCC test procedures[35] showed that such acceleration of corrosion losses under the application of stress can result from the presence of fine transgranular cracks emanating from surface pits. Such cracking is not considered to be indicative of susceptibility to SCC.

C.3. Resistance to SCC-Precracked Specimens

Tables LI through LIII list the plate, die forgings, and extruded shapes which were tested with short-transverse (S-L), tension precracked DCB specimens. Pertinent measurements and initial (K_{Ii}) and final (K_{If}) stress-intensity calculations are listed for the individual test specimens. The results of plane-strain fracture toughness tests of these materials are also shown.

Figure 167 illustrates the increase in crack length during exposure. Bands are shown to illustrate the range of results seen with various samples of each product; representative crack-growth curves for DCB specimens from 7079-T651, 7075-T651 and 7075-T7351 plate are also shown. Individual crack-growth curves for specimens from each of the 7050 products tested were shown in the tenth bi-monthly progress report.

A small amount of crack growth was noted in the specimens from the 7050-T73651 plate, slightly more than that seen in similar tests of 7075-T7351 plate, but considerably less than that incurred in tests of susceptible plate materials such as 7075-T651 and 7079-T651. Specimens from the 7050-T736 die forgings and 7050-T76511 extruded shapes experienced significantly greater amounts of crack growth than specimens from the plate. Although comparative data are not available for similar products of other alloys, it is considered significant that the greatest amount of crack growth seen in tests of either die forgings or extruded shapes was also somewhat less than that developed in the 7075-T651 and 7079-T651 plate.

Metallographic examination of representative specimens showed that the environmental crack growth in each product was the result of typical intergranular SCC. Figs. 168 through 170 illustrate the intergranular or interfragmentary nature of the SCC in the various products. No transgranular cracking was detected in the precracked specimens.

Crack-growth rate versus stress intensity data were also developed for each of the products tested. However, before considering these data, several pertinent observations must be made. Plastic bending occurred in the arms of most specimens during loading to pop-in. This bending generally was rather slight for most of the die forged and extruded specimens, and had little significant effect on the level of calculated stress-intensity; i.e., the K_{Ii} values agreed well with the valid K_{Ic} values determined with compact tension specimens (Tables LII and LIII). The plasticity effects resulted in somewhat higher COD measurements for the plate samples, and the calculated stress-intensities were inordinately high (Table LI). Excessive stress-intensity values were also noted for certain die forged specimens due to the crack front deviating from the intended plane of fracture (Fig. 17); data for these die forged specimens were not utilized in the K-rate determinations.

"Plateau" velocities for the K-rate curves were determined by an arbitrary procedure to avoid the erratic shapes of crack-growth curves during the initiation of SCC, and the extraneous effect of corrosion product wedging. The total amount of crack growth in inches that occurred during the first 360 hours (15 days) was used to calculate the overall average growth rate for that period. This method was found to best represent the initial sustained crack growth which is considered to be one of the most significant features of the K-rate graphs.

The K_I rate data for the 7050 alloy products are illustrated in Fig. 172. Data for plate of alloys 7079-T651, 7075-T651 and 7075-T7351 again are shown for comparison. The data showed SCC "plateau" velocities for the products tested of:

Product	SCC Velocity, in./hr. Range	SCC Velocity, in./hr. Average
7050-T73651 Plate	7.5×10^{-5} to 3×10^{-4}	1.4×10^{-4}
7050-T736 Die Forgings	2.9×10^{-4} to 7.9×10^{-4}	4.5×10^{-4}
7050-T76511 Extruded Shapes	3.3×10^{-4} to 8.2×10^{-4}	5.8×10^{-4}

The data provide questionable values of K_{Ith} due to the high calculated stress intensities (non plane-strain) for the plate, and the fact that crack growth in specimens of the die forgings and extruded shapes did not reach an actual arrest due to corrosion product wedging. However, if the threshold stress

intensity is expressed as a ratio of final and initial calculated stress intensities for individual specimens

$$\frac{K_{If}}{K_{Ii}\ (\text{Pop-In})}$$

the data provide estimated K_{Ith} values of:

Product	Apparent K_{Ith}
7050-T73651 Plate	81-95% K_{Ii}
7050-T736 Die Forgings	58-80% K_{Ii}
7050-T76511 Extruded Shapes	54-79% K_{Ii}

Since the calculated K_{Ii} values for the die forgings and extruded shapes showed good agreement with valid K_{Ic} values, these are considered to be reasonable approximations of K_{Ith} for those products. Although these estimated threshold stress intensities may be considered technically invalid (due to plasticity effects or curvature of the crack fronts), they are considered meaningful because there is ample evidence to show that the occurrence of SCC in aluminum alloy products does not require a plane-strain state of stress.

Supplemental Tests - Ring-Loaded Compact Tension Specimens

As a result of the experimental difficulties encountered in estimating threshold stress intensities by the "crack-arrest" procedure discussed above, a limited number of additional tests were conducted to check the apparent threshold stress intensity for a single lot of both the plate and extruded shapes by the "crack-initiation" procedure. Details of the latter procedure are given in a paper (36) presented at the 1974 Tri-Service Conference on Corrosion of Military Equipment and to be published in the proceedings of that conference.

Table LIV summarizes the results of ring-loaded SCC initiation tests of compact tension specimens (S-L orientation) from one lot of 4-in. thick plate and the 5.0x6.25-in. extruded shape. The specimens were fatigue precracked prior to loading, and the corrodent was a 3.5% NaCl solution applied dropwise three times daily except for weekends and holidays.

Applied stress intensity values were chosen to cover a range extending below the threshold values indicated by the DCB tests. Target values for specimens from the 7050-T73651 plate were therefore chosen at 98, 90, 85 and 75 per cent of the critical stress intensity. The calculated initial stress intensity (K_{Ii}) was generally higher than the target value, and the specimen loaded to the target value of 98% K_{Ic} actually exceeded the critical stress-intensity factor with attendant rapid failure. SEM examination of the fracture indicated that the failure had not been environmentally assisted. The remaining samples loaded to K_{Ii} values of 96, 88 and 79 per cent of K_{Ic} all showed small but significant amounts of crack growth which subsequent fractographic or metallographic examination showed to be intergranular and typical of SCC. The crack-growth rate was very slow in all specimens, and the specimen loaded to the K_{Ii} level of 79% K_{Ic} had not failed prior to removal from test at 3600 hours (150 days), indicating that this value of K_{Ii} was very close to the threshold stress intensity.

Specimens from the 7050-T76511 extruded section loaded to K_{Ii} values of 85, 75, 62 and 53 per cent of K_{Ic} all showed significant amounts of environmental crack growth which fractographic examination confirmed to be SCC. The SCC growth developed very slowly in the specimen loaded to 53% K_{Ic}, and failure did not occur until 2860 hours (120 days), suggesting that this specimen was loaded only slightly above the threshold stress intensity.

The apparent levels of K_{Ith} indicated by the ring load, "crack-initiation" tests are listed below together with the range of apparent K_{Ith} values estimated by the "crack-arrest" tests discussed in the previous section.

	Apparent K_{Ith}	
	Ring Load, Compact	Bolt Load, DCB
7050-T73651 Plate	78% K_{Ic}	81-95% K_{Ii}
7050-T76511 Extruded Shapes	50% K_{Ic}	54-79% K_{Ii}

There appears to be reasonable agreement between the threshold stress-intensity values estimated by the two test procedures.

SECTION VI

SUMMARY AND CONCLUSIONS

Alloy 7050, developed to have a combination of high strength, high resistance to corrosion and good fracture toughness, has been evaluated for mechanical properties and corrosion resistance from tests of T76 sheet, T73651 plate, T73652 hand forgings, T736 die forgings and T76511 extruded shapes produced by commercial practices. Based on these test results the following summary statements and conclusions have been made:

GENERAL

Commercially produced products of 7050 are capable of developing a combination of high strength, high resistance to corrosion and good fracture toughness that is more attractive than that of commercially established alloys.

A. Mechanical Properties

1. The minimum tensile yield strengths, tentatively selected on the basis of yield strength-corrosion resistance correlations, appear reasonable, with the possible exception that for certain extruded shapes it may be necessary to lower either the minimum and maximum yield strengths or the tentative stress-corrosion test capability based on the results of the corrosion tests.

2. The maximum yield strengths for plate and hand forgings greater than 3-in. in thickness have been increased on the basis of data obtained in this contract.

3. Based on yield strength-ultimate strength relationships, the minimum ultimate strengths, with the possible exception of those for plate, should be reevaluated when sufficient production data are obtained.

4. Design mechanical properties have been established using derived minimum ratios developed statistically from ratios among tensile, compressive, shear and bearing properties.

5. The modulus of elasticity values of 7050 products are generally within 2 per cent of those of other 7XXX alloys. Above 25 ksi the compressive modulus increases as the stress increases.

The average modulus values of each product are as follows:

Product	Temper	0 to 25 ksi Tension	0 to 25 ksi Compression	0 to E.L.* Compression
Sheet	T76	10.2	10.5	10.6
Plate	T73651	10.3	10.5	10.6
Hand Forgings	T73652	10.2	10.5	10.6
Die Forgings	T736	10.2	10.5	10.7
Extruded Shapes	T76511	10.3	10.6	10.7

* Stress range: 0 to elastic limit

6. Tensile and compressive stress-strain curves for five samples of each product, shown in Figs. 51 to 83, represent data suitable for use in establishing typical tensile and compressive stress-strain curves when sufficient production data are obtained to set typical tensile properties.

A.2. Fracture Toughness

1. No K_c data for tests made with anti-buckling guides are available for other sheet alloys for comparative purposes, but the strength-toughness combination indicated for 7050-T76 sheet is higher than most conventional alloys and can approach that of 7475 sheet. Tests of 0.063-in. sheet indicate that the strength and toughness levels obtained for 7050-T76 are dependent on composition.

2. Generally, 7050 plate, hand forgings, die forgings and extruded shapes exhibit a higher combination of strength and toughness, K_{Ic}, than established commercial alloys and tempers.

A.3. Axial-Stress Fatigue

1. The axial-stress fatigue strengths for smooth and notched, $K_t=3$, specimens of the 7050 products are in about the same general range as those for corresponding products of 7XXX alloys in the T7XXX tempers.

2. The fatigue strengths of 7050 plate, hand forgings and extruded shapes tested in salt fog are generally equivalent.

3. The effect of the salt-fog environment is greatest at the longer lives; at these lives the corrosion fatigue strengths of the 7050 products are somewhat lower than reported for 7475-T761 sheet, 2124-T851 plate and 7049-T73 and 7175-T736 hand forgings.

B. Fatigue-Crack Propagation

1. Similar crack propagation is generally obtained from T-L specimens of the thinner products of the plate, hand forgings and extruded shapes.

2. At the higher stress intensities, crack propagation occurs significantly faster in the longitudinal direction than in the transverse direction of the thick extruded shapes and hand forgings; no such behavior occurs in plate.

3. Propagation in humid air and in salt fog for the various products tends to be faster than in dry air by factors of about two and three, respectively.

4. The rates of propagation for T-L specimens are generally comparable to those reported earlier for tests of corresponding products of other aircraft alloys.

C. Corrosion Characteristics

1. All products showed a high order of resistance to exfoliation in the accelerated test media, generally showing either no exfoliation or only minor exfoliation (visual rating of degree E-A) which is not considered to be of practical significance in regard to service performance.

2. The sheet, plate and forged products all showed good resistance to stress-corrosion cracking, in line with the proposed targets for resistance to SCC (Table L).

3. The extruded shapes, with the exception of short-transverse specimens from the 1.5x7.5-in. rectangular bar, also demonstrated the SCC resistance expected of the product. Additional aging at 325 F (5 hours) developed the expected level of SCC resistance in the 1.5x7.5-in. rectangle with some decrease in mechanical properties.

4. Atmospheric test results have shown no SCC failures of specimens of sheet, plate and hand forgings in tests of 605 and 763 days duration. Seacoast atmospheric failures have occurred at stresses of 35 ksi with specimens from four of ten 7050-T736 die forgings tested, and at 25 ksi with specimens from two or four 7050-T76511 extruded shapes. In the industrial atmosphere only one specimen of a die forging has failed at 45 ksi.

5. Tests of precracked DCB specimens from the plate, die forgings and extruded shapes showed the same general trends seen with tests of smooth specimens, and would result in a similar ranking of the three products. Analyses of the crack-growth data resulted in the following estimates of average SCC "plateau" velocities and K_{Ith}.

Product	Crack Velocity in./hr.	K_{Ith} %K_{Ii}	Ring-Loaded Compact K_{Ith} %K_{Ic}
7050-T73651 Plate	$1x10^{-4}$	81-95	78
7050-T736 Die Forgings	$5x10^{-4}$	58-80	--
7050-T76511 Extruded Shapes	$6x10^{-4}$	54-79	50

REFERENCES

1. J. T. Staley, "Investigation to Improve the Stress-Corrosion Resistance of Aluminum Aircraft Alloys Through Alloy Additions and Specialized Heat Treatment," Final Report under Naval Air Systems Command Contract N00019-68-C-0146, February 1969.

2. J. T. Staley, "Investigation to Develop a High-Strength, Stress-Corrosion Resistant Aluminum Aircraft Alloy," Final Report under Naval Air Systems Command Contract N00019-69-C-0292, January 1970.

3. J. T. Staley, "Investigation to Develop a High-Strength, Stress-Corrosion Resistant Naval Aircraft Alloy," Final Report under Naval Air Systems Command Contract N00019-70-C-0118, November 1970.

4. J. T. Staley, "Further Development of Aluminum Alloy X7050", Final Report under Naval Air Systems Command Contract N00019-71-C-0131, May 1972.

5. Military Standardization Handbook, Metallic Materials and Elements for Aerospace Vehicle Structures, Volume 1, September 1, 1971.

6. "Standard Methods of Verification of Testing Machines, E4-72", 1973 Book of ASTM Standards, Part 31.

7. G. W. Stickley and D. J. Brownhill, "Mechanical Properties of Stress-Relieved Stretched Aluminum Alloy Plate", Technical Report AFML-TDR-64-105, May 1964.

8. J. G. Kaufman, G. E. Nordmark and B. W. Lifka, "Fracture Toughness, Fatigue and Corrosion Characteristics of 7075-T651, 7075-T7351 and 7079-T651 Aluminum Alloys", Technical Report AFML-TR-65-170, May 1965.

9. J. G. Kaufman, G. E. Nordmark and B. W. Lifka, "Fracture Toughness, Fatigue and Corrosion Characteristics of 2020-T651, 2024-T851, 2219-T851 and 7001-T75 Aluminum Alloys", Technical Report AFML-TR-66-291, September 1966.

10. D. J. Brownhill, R. E. Davies and D. O. Sprowls, "Mechanical Properties, Including Fracture Toughness and Fatigue, and Resistance to Stress Corrosion Cracking, of Stress-Relieved Stretched Aluminum Alloy Extrusions", Technical Report AFML-TR-68-34, Fabruary 1968.

11. D. J. Brownhill, C. F. Babilon, G. E. Nordmark and D. O. Sprowls, "Mechanical Properties Including Fracture Toughness and Fatigue, Corrosion Characteristics and Fatigue Crack Propagation Rates of Stress-Relieved Aluminum Alloy Hand Forgings", Technical Report AFML-TR-70-10, February 1970.

12. C. F. Babilon, R. H. Wygonik, G. E. Nordmark and B. W. Lifka, "Mechanical Properties, Fracture Toughness, Fatigue, Environmental Fatigue Crack Growth Rates and Corrosion Characteristics of High Toughness Aluminum Alloy Forgings, Sheet and Plate", Technical Report AFML-TR-73-83, April 1973.

13. "Standard Methods of Tension Testing Wrought and Cast Aluminum and Magnesium Alloy Products, B557-73", 1974 Book of ASTM Standards, Part 7.

14. "Standard Methods of Tension Testing of Metallic Materials, E8-69", 1973 Book of ASTM Standards, Part 31.

15. "Standard Methods of Compression Testing of Metallic Materials, E9-70", 1973 Book of ASTM Standards, Part 31.

16. R. E. Davies and J. G. Kaufman, "Effects of Test Method and Specimen Orientation on Shear Strengths of Aluminum Alloys", ASTM Proceedings, Vol. 64, 1964, pp. 999-1010.

17. "Standard Method for Pin-Type Bearing Test of Metallic Materials, E238-68", 1973 Book of ASTM Standards, Part 31.

18. "Standard Method for Determination of Young's Modulus at Room Temperature, E111-61", 1973 Book of ASTM Standards, Part 31.

19. "Standard Method of Verification and Classification of Extensometers, E83-67", 1973 Book of ASTM Standards, Part 31.

20. J. G. Kaufman and A. H. Knoll, "Kahn-Type Tear Tests and Crack Toughness of Aluminum Sheet," Materials Research and Standards, Vol. 4, No. 4, April 1964, pp. 151-155.

21. "Fracture Testing of High Strength Sheet Materials", ASTM Bulletin No. 243, January 1960, p. 29; also No. 244, February 1960, p. 18.

22. C. E. Feddersen, "Evaluation and Prediction of the Residual Strength of Center-Cracked Tension Panels," Battelle Memorial Institute, Columbus, Ohio (presented at the ASTM Annual Meeting, Toronto, Canada, June 1970).

23. "Standard Method of Test for Plane-Strain Fracture Toughness of Metallic Materials, E399-72", 1973 Book of ASTM Standards, Part 31.

24. W. F. Brown, Jr. and J. E. Srawley, "Plane Strain Crack Toughness Testing of High Strength Metallic Materials", ASTM STP No. 410, 1967.

25. W. G. Clark, Jr., ASTM E24.4, "Fatigue Crack Growth Rate Testing Round Robin Program", Task Group Progress Report No. 3, May 14, 1971.

26. "Standard Method of Test for Exfoliation Corrosion Susceptibility in 7XXX Series Copper-Containing Aluminum Alloys (EXCO Tests)", G34-72, 1973 Book of ASTM Standards, Part 31.

27. B. W. Lifka and D. O. Sprowls, "An Improved Exfoliation Test for Aluminum Alloys," Corrosion, Vol. 22, No. 1, 1966, pp. 7-15.

28. "Federal Test Method Standard No. 151b", November 1967.

29. M. V. Hyatt, "Use of Precracked Specimens in Stress-Corrosion Testing of High-Strength Aluminum Alloy", Corrosion, Vol. 26, No. 11, November 1970, pp 487-503.

30. Unpublished Data, Alcoa Laboratories.

31. R. E. Jones and K. A. Fudge, "Engineering Design Data For Aluminum Alloy 7050-T73651 Plate", Technical Report AFML-TR-73-269, November 1973.

32. D. O. Sprowls and B. W. Lifka, "Relationship of Accelerated Test Methods for Exfoliation Resistance in 7XXX Series With Exposure to a Seacoast Atmosphere", Corrosion in Natural Environments, ASTM STP558, 1974.

33. D. O. Sprowls, T. J. Summerson and F. E. Loftin, "Exfoliation Corrosion Testing of 7075 and 7178 Aluminum Alloys - Interim Report on Atmospheric Exposure Tests", Corrosion in Natural Environments, ASTM STP558, 1974.

34. "Production of Extrusions From Aluminum Alloy 7050", AFML Contract No. F33615-73-C-5015, Interim Engineering Progress Report, December 14, 1973.

35. Lifka, B. W., Sprowls, D. O. and Kelsey, R. A., "Investigation of Smooth Specimen SCC Test Procedures-Variations in Environment, Specimen Size, Stressing Frame, and Stress State," Final Report of Government Contract NAS 8-21487 - Part II, August 1972.

36. J. G. Kaufman, J. W. Coursen and D. O. Sprowls, "An Automated Method for Evaluating Resistance to Stress-Corrosion Cracking with Ring-Loaded Precracked Specimens."

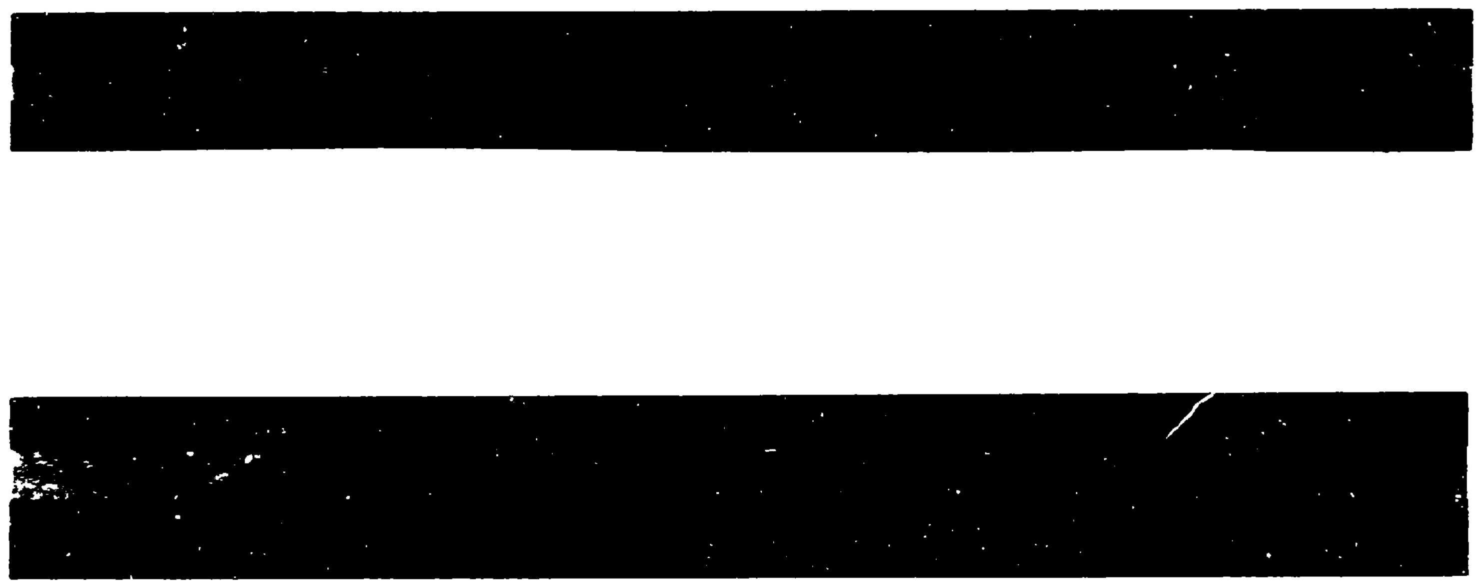


Fig. 1 Etched Cross Sections of 7050-T73651 Plate, 0.500-in. Thick.

Fig. 1

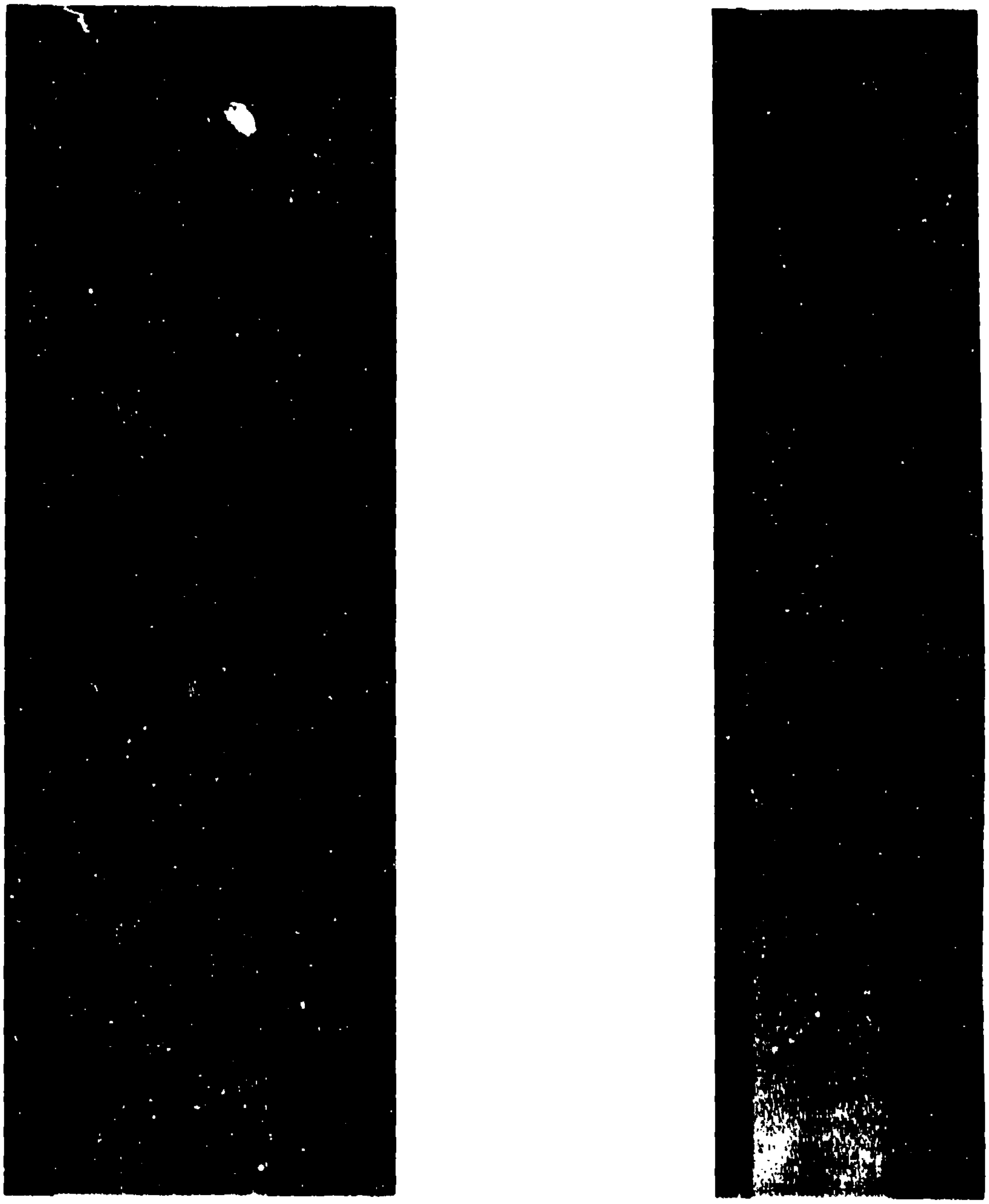


Fig. 2 Etched Cross Sections of 7050-T73651 Plate, 1.000-in. Thick.

Fig. 2

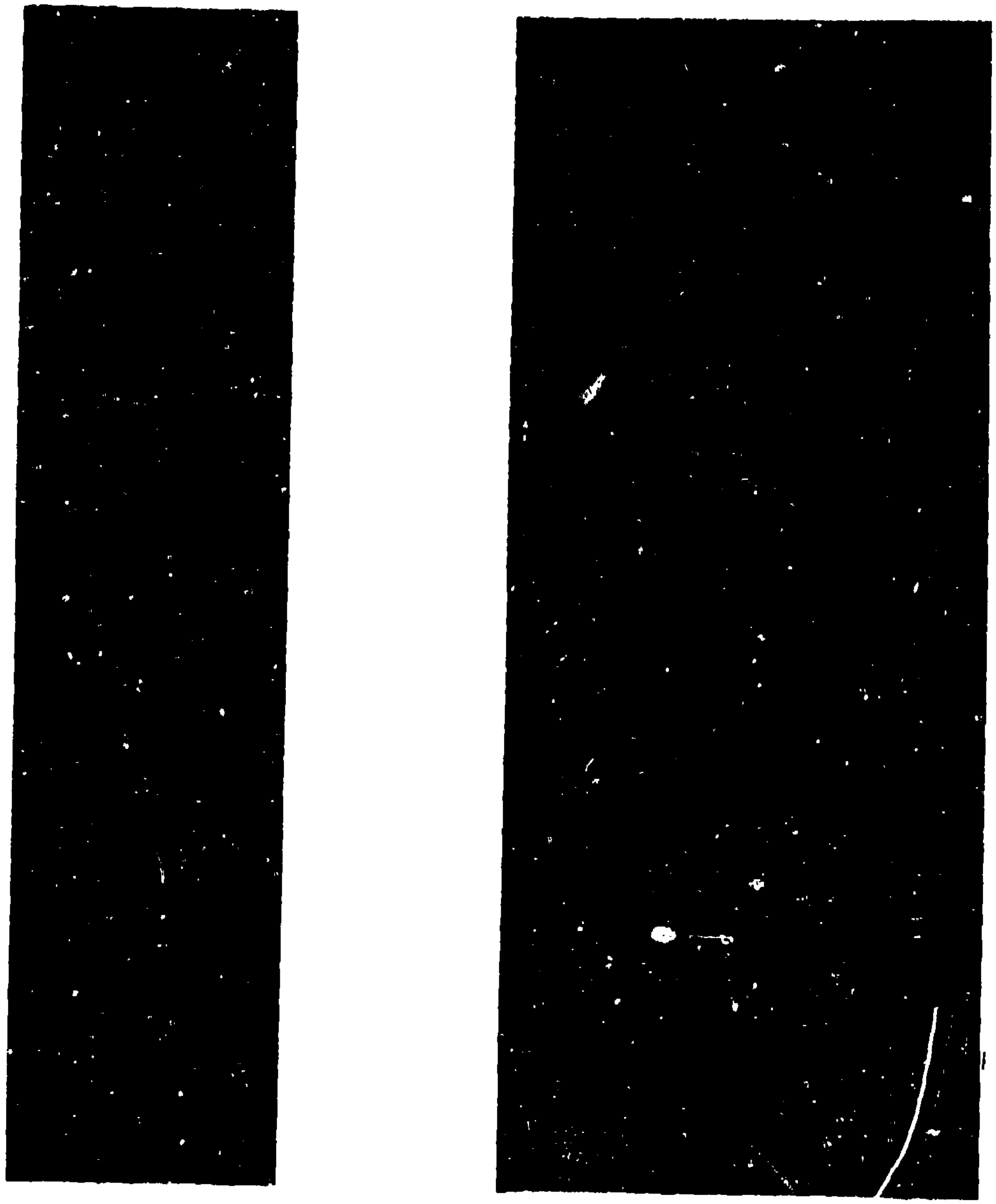


Fig. 3 Etched Cross Section of 7050-T73651 Plate, 2.000-in. Thick.

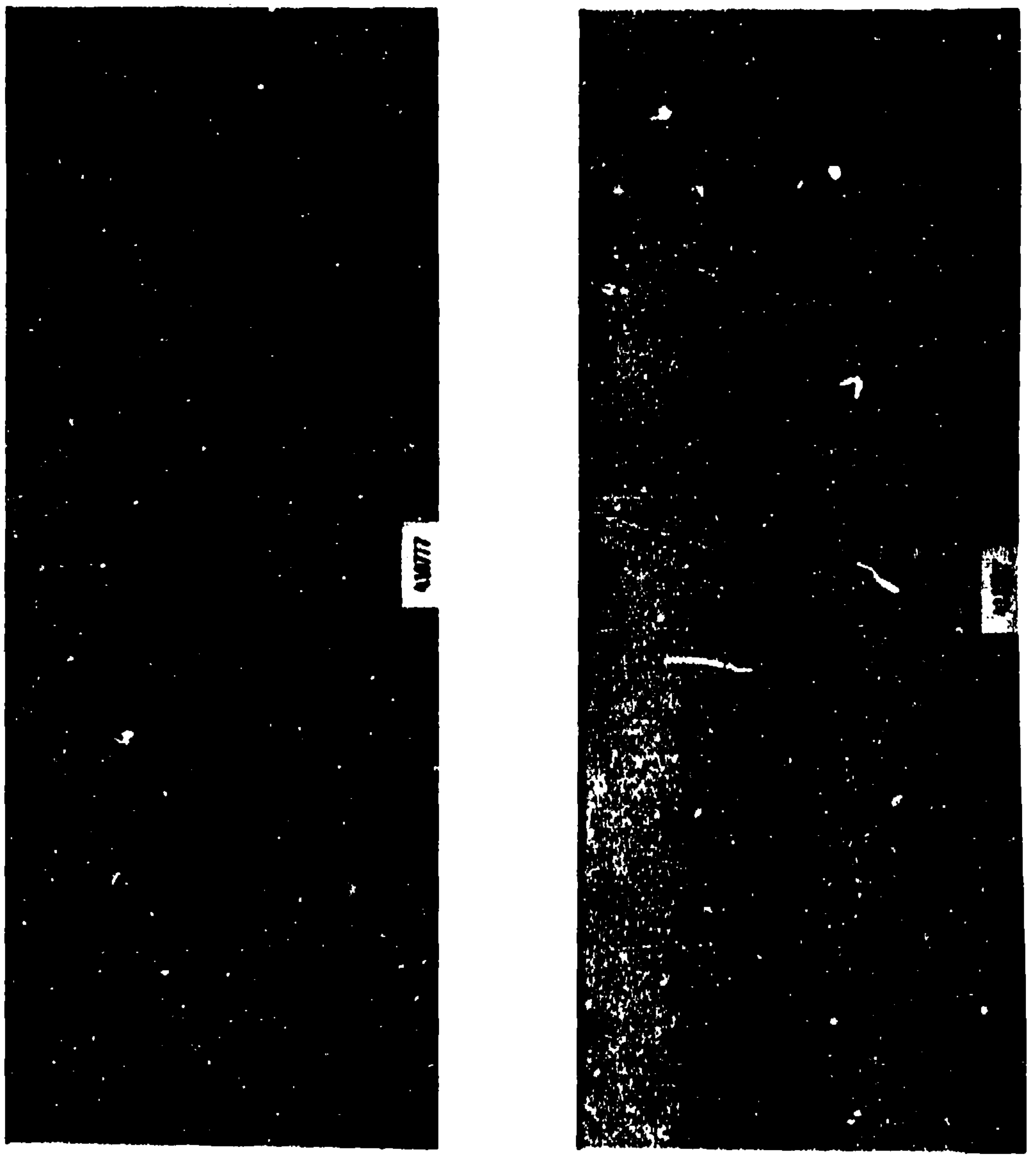


Fig. 4 Etched Cross Sections of 7050-T73651 Plate, 4.000-in. Thick.

Fig. 4

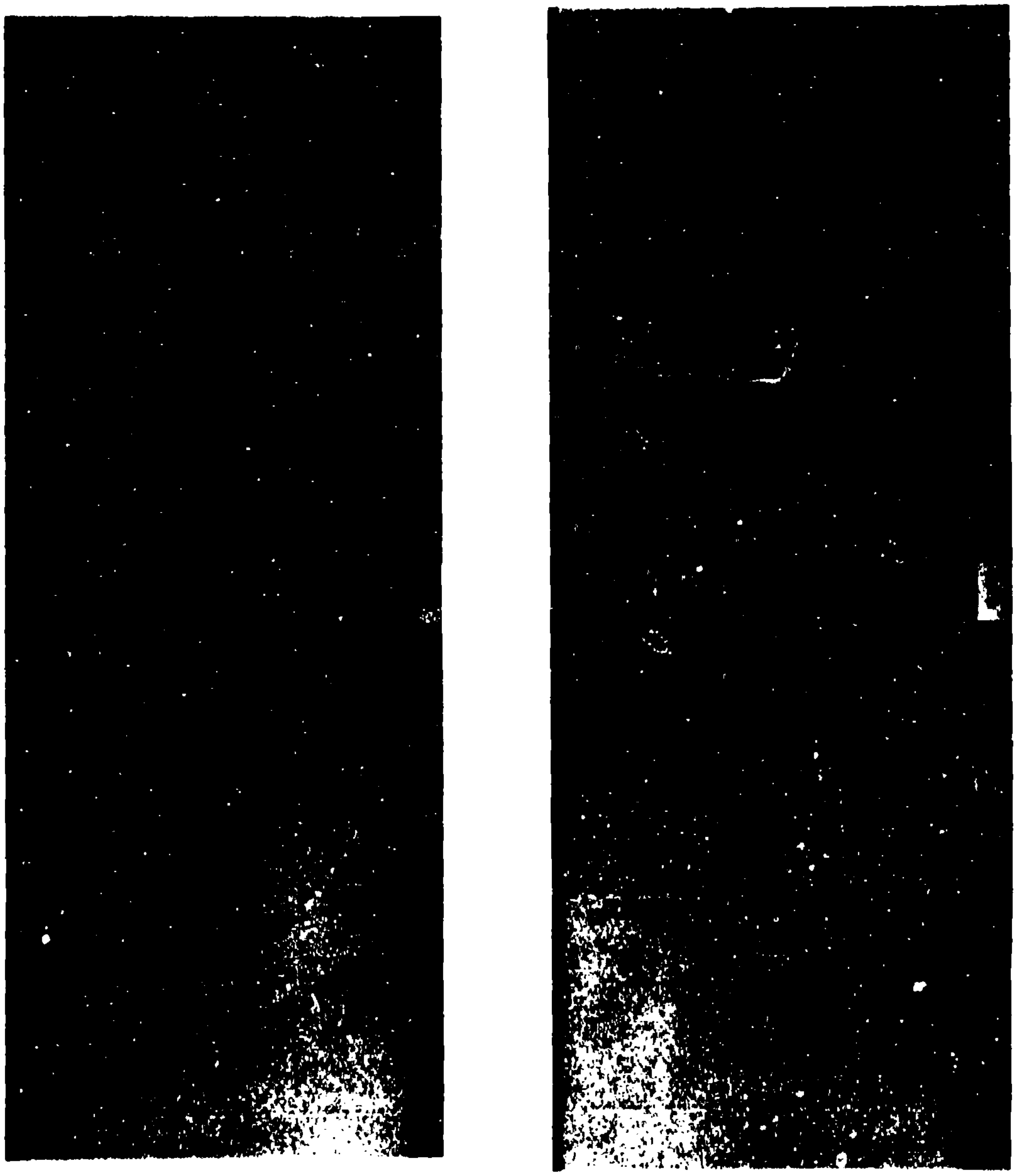
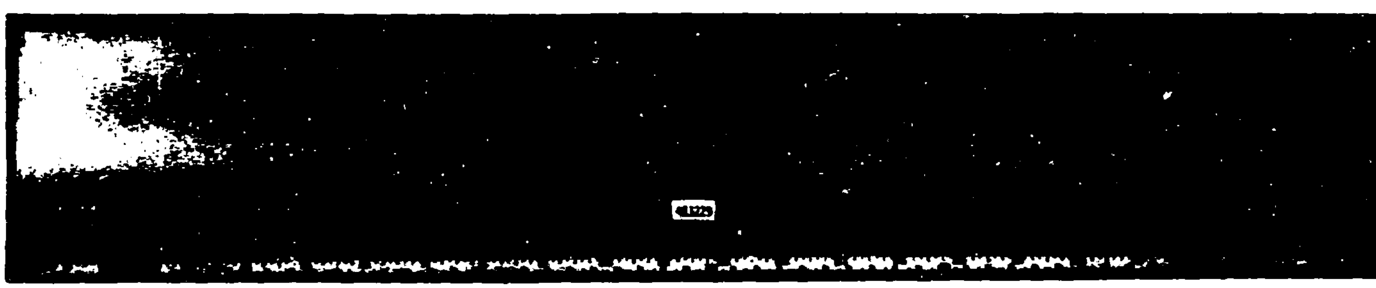


Fig. 5 Etched Cross Sections of 7050-T73651 Plate, 6.000-in. Thick.

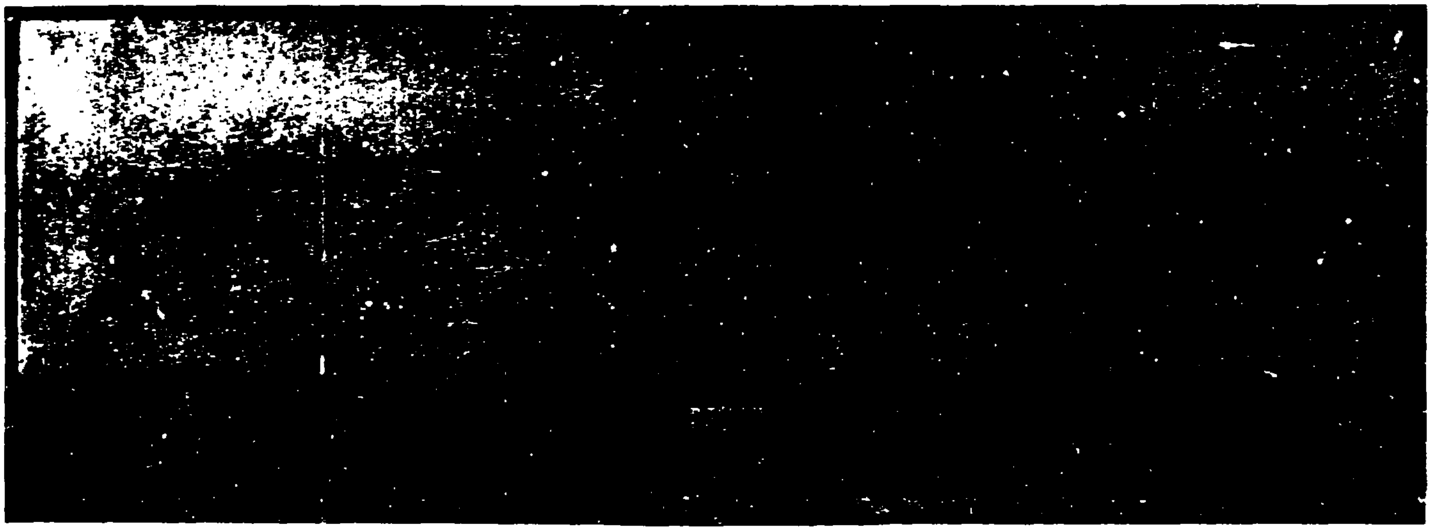
2 x 8 x 72 in.



2-1/2 x 22 x 60 in.

Fig. 6 Etched Cross Sections of 7050-T73652 Hand Forgings

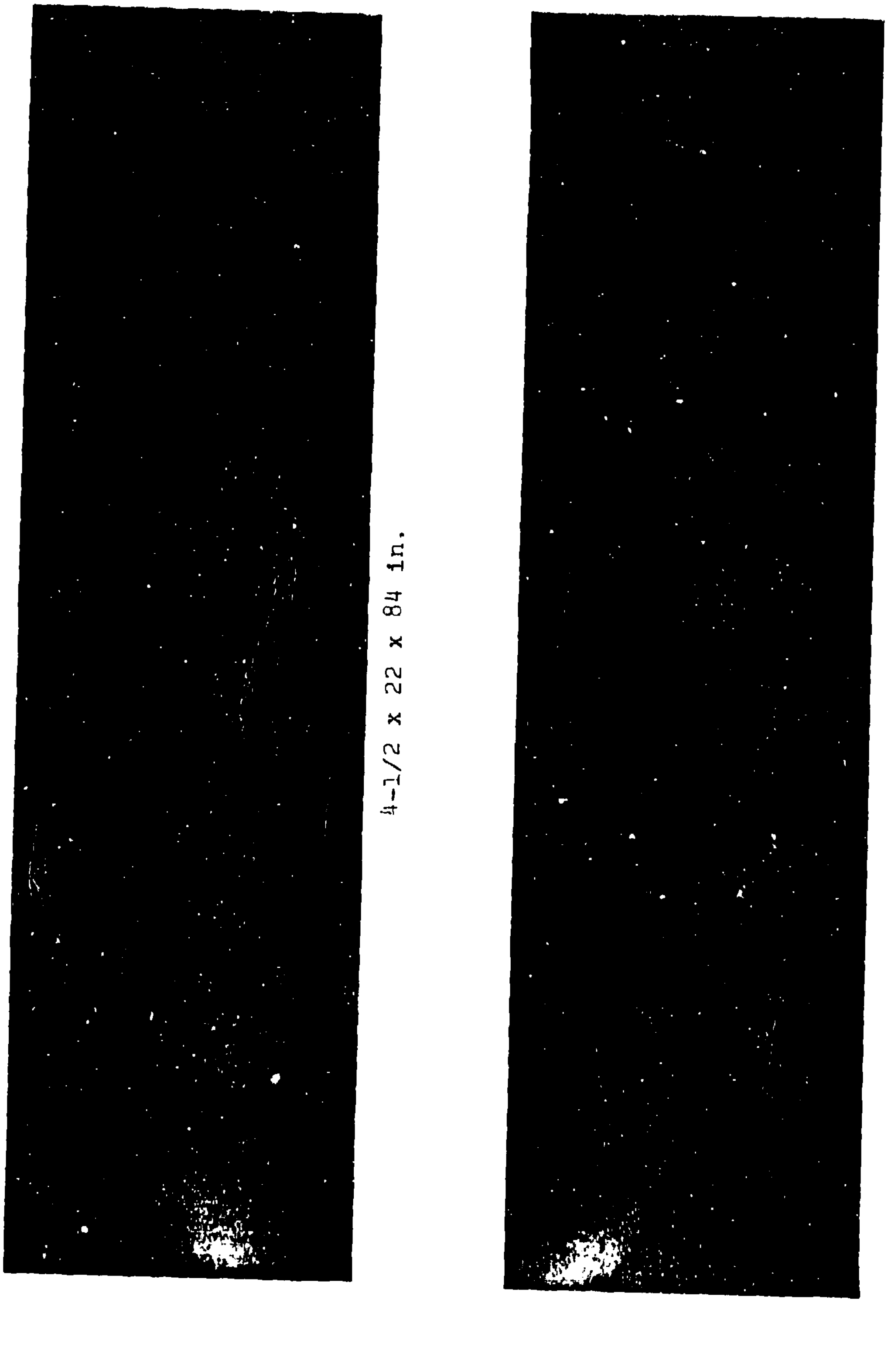
3-1/2 x 22 x 84 in.



3-1/2 x 14 x 74 in.

Fig. 7 Etched Cross Sections of 7050-T73652 Hand Forgings

Fig. 7



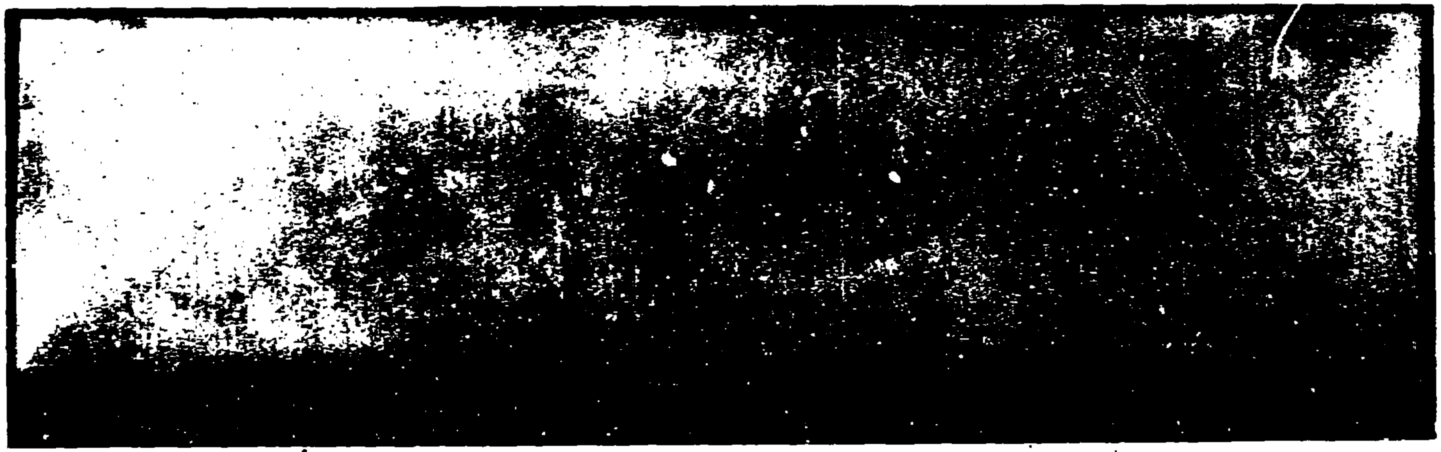
4-1/2 x 22 x 84 in.

4-1/2 x 22 x 84 in.

Fig. 8 Etched Cross Sections of 7050-T73652 Hand Forgings

Fig. 8

5-1/2 x 22 x 60 in.



5-1/2 x 22 x 45 in.

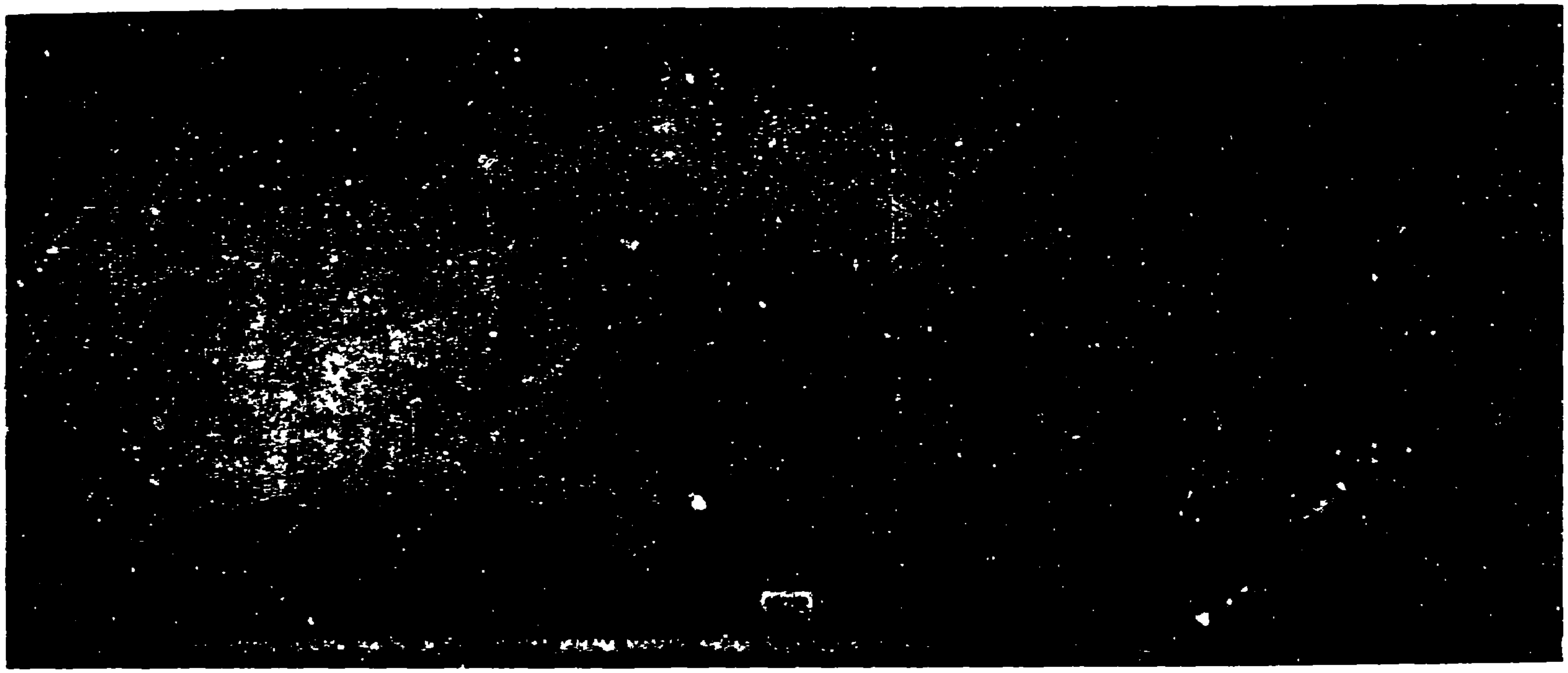
Fig. 9 Etched Cross Sections of 7050-T73652 Hand Forgings

Fig. 9

Fig. 10 Etched Cross Section of 7050-T73652 Hand Forging

7-1/2 x 22 x 42 in.

Fig. 10



7-1/2 x 22 x 42 in.

Fig. 11 Etched Cross Section of 7050-T73652 Hand Forging

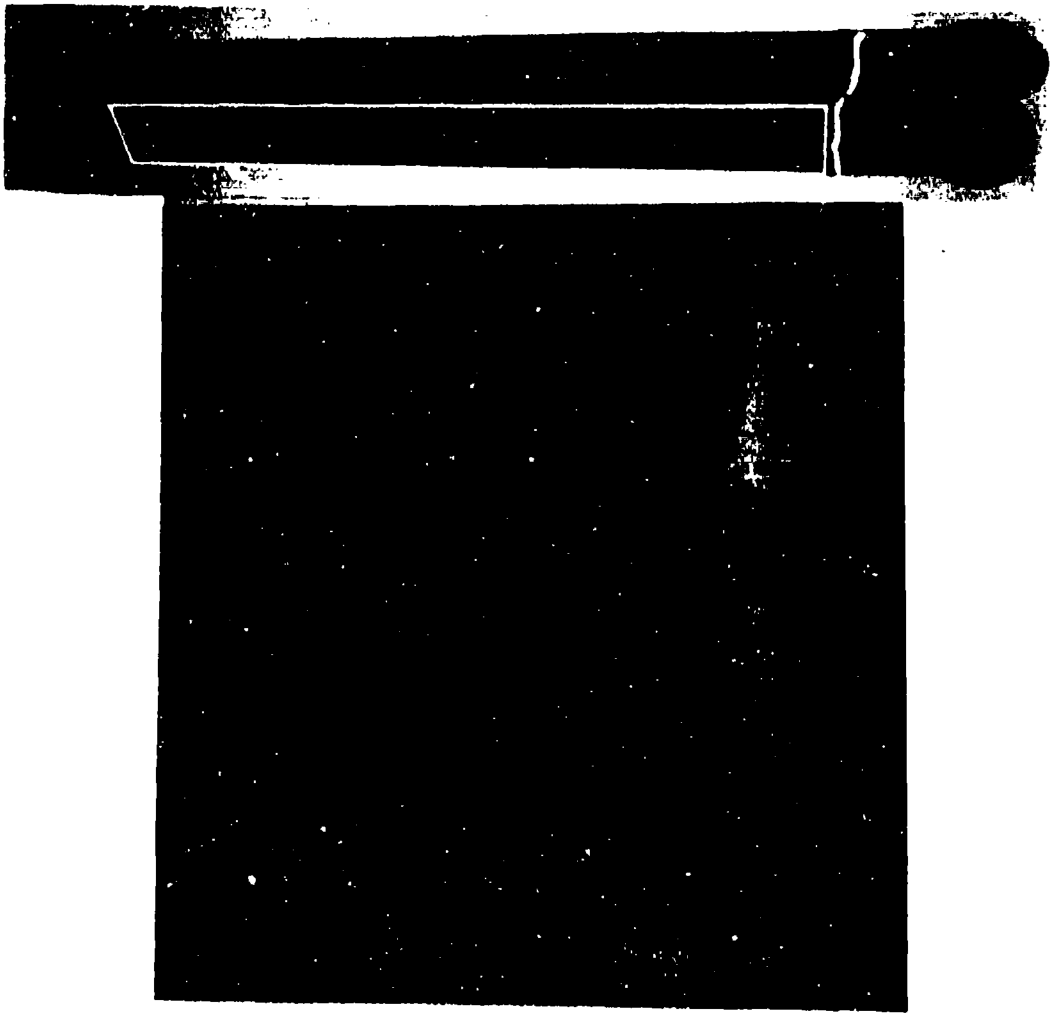


Fig. 12 Etched Cross Section of 7050-T736 Die Forging (Die No. 2177)

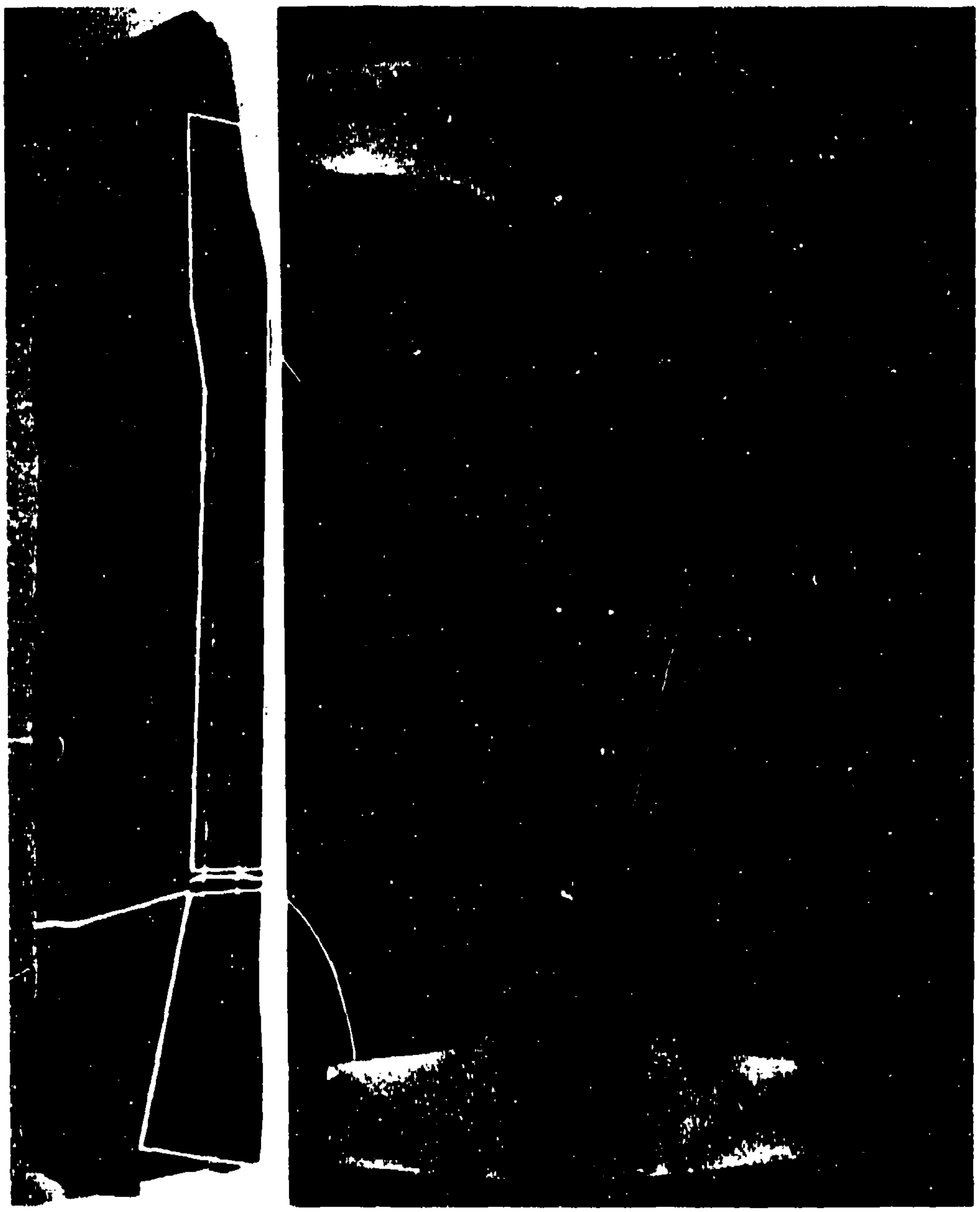


Fig. 13 Etched Cross Section of 7050-T736 Die Forging (Die No. 9078)

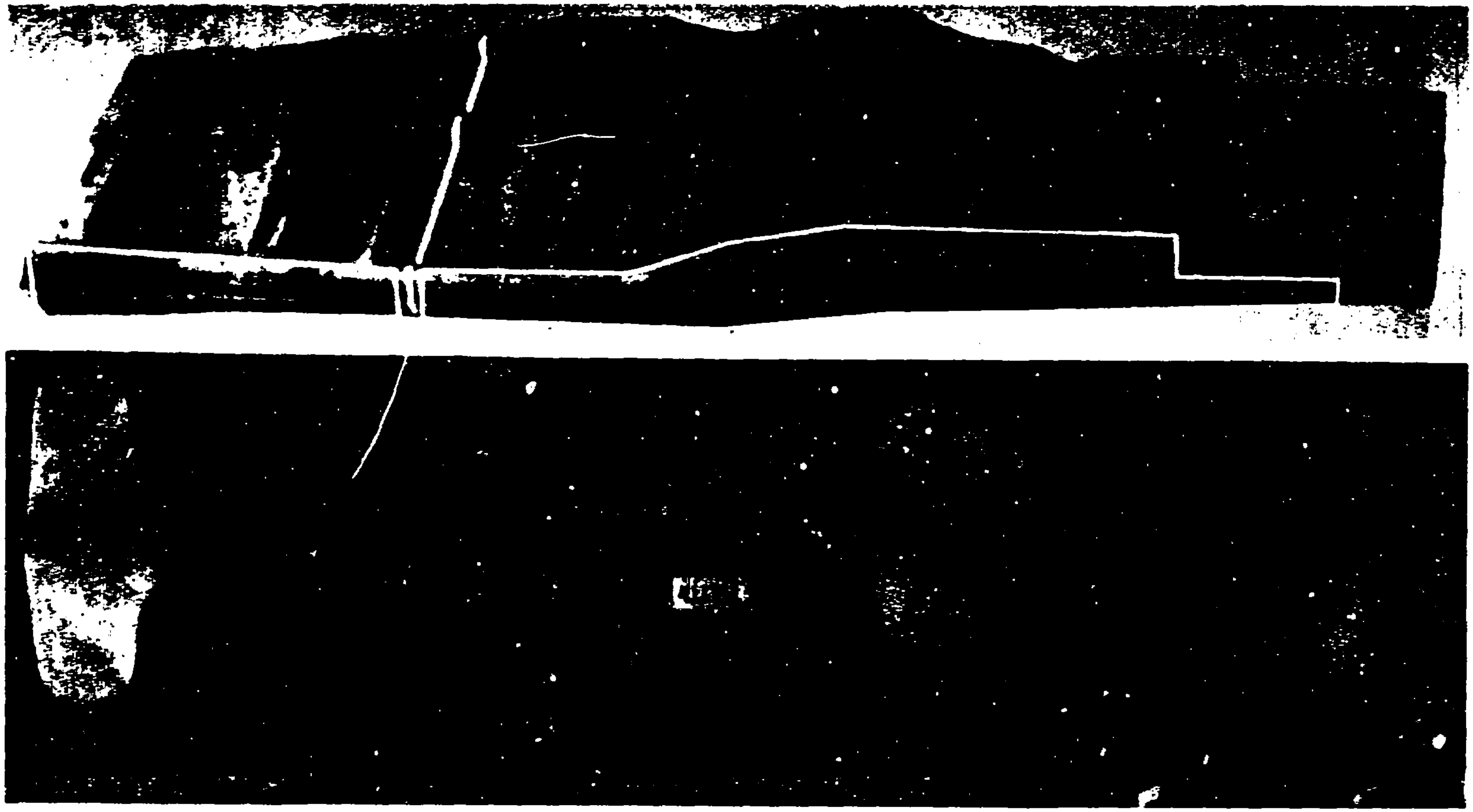


Fig. 14 Etched Cross Section of 7050-T736 Die Forging (Die No. 15789)

Fig. 14

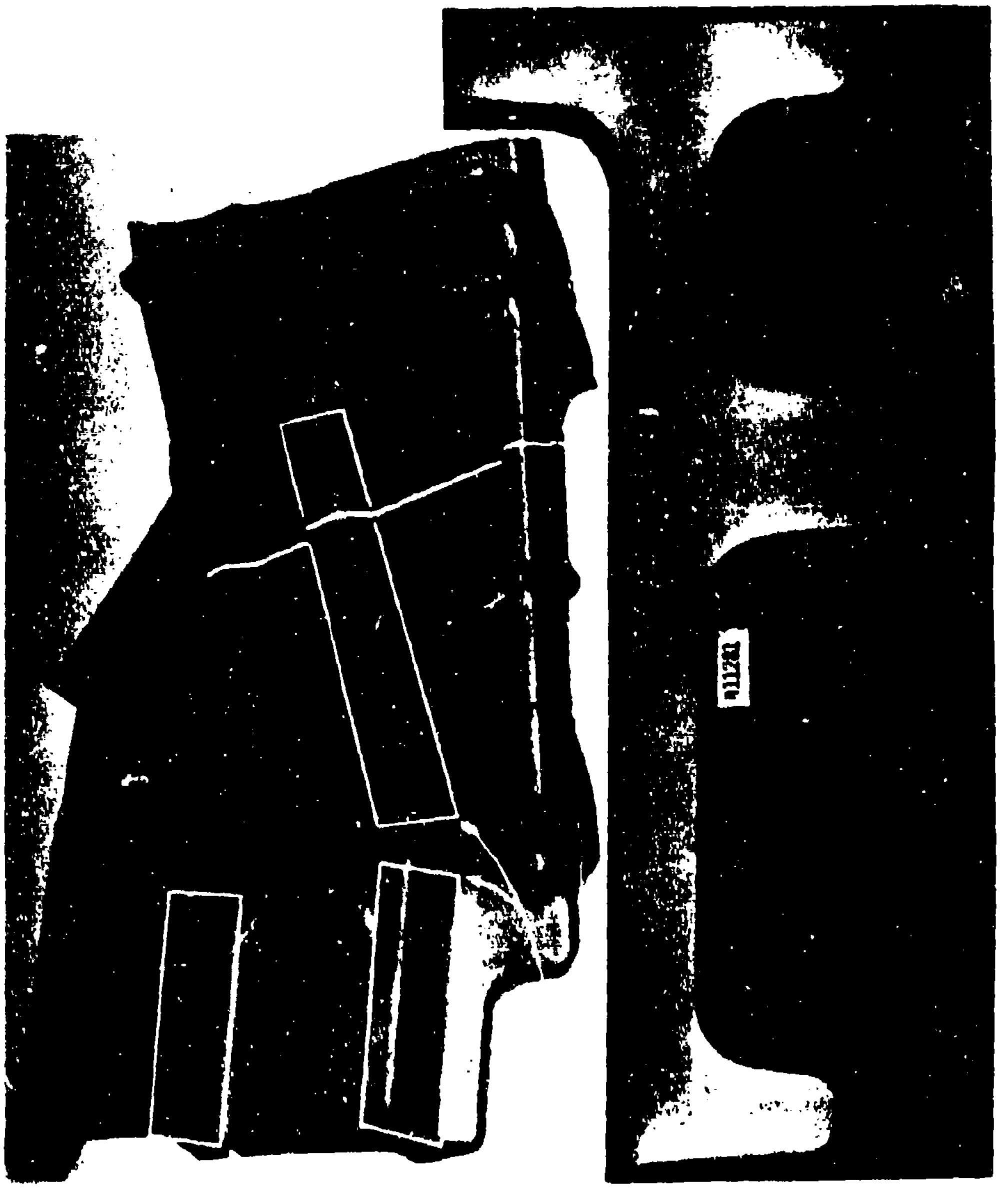


Fig. 15 Etched Cross Section of 7050-T736 Die Forging (Die No. 17975)

Fig. 15

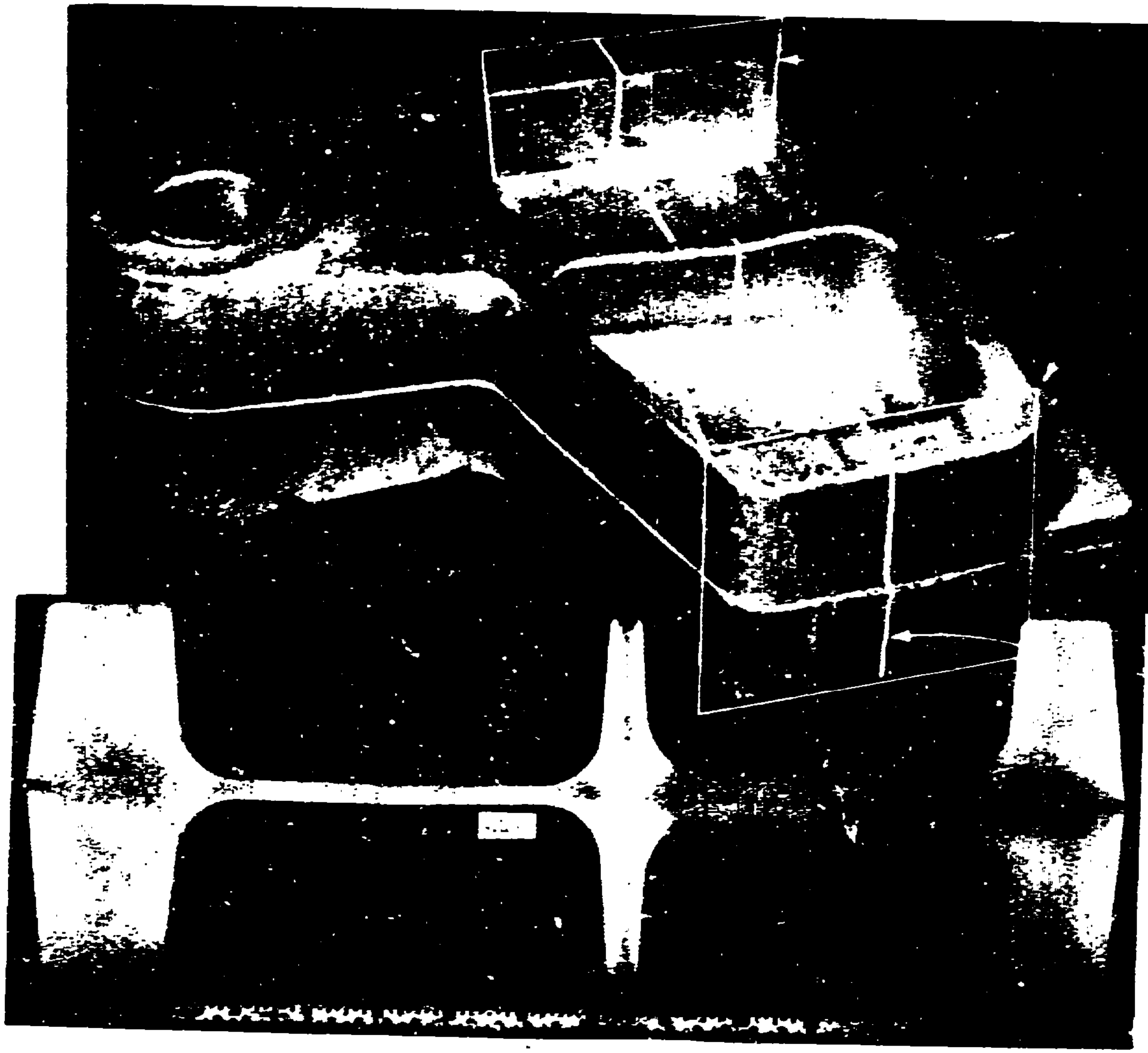


Fig. 16 Etched Cross Section of 7050-T736 Die Forging (Die No. 17944)

0J06864
C30:382

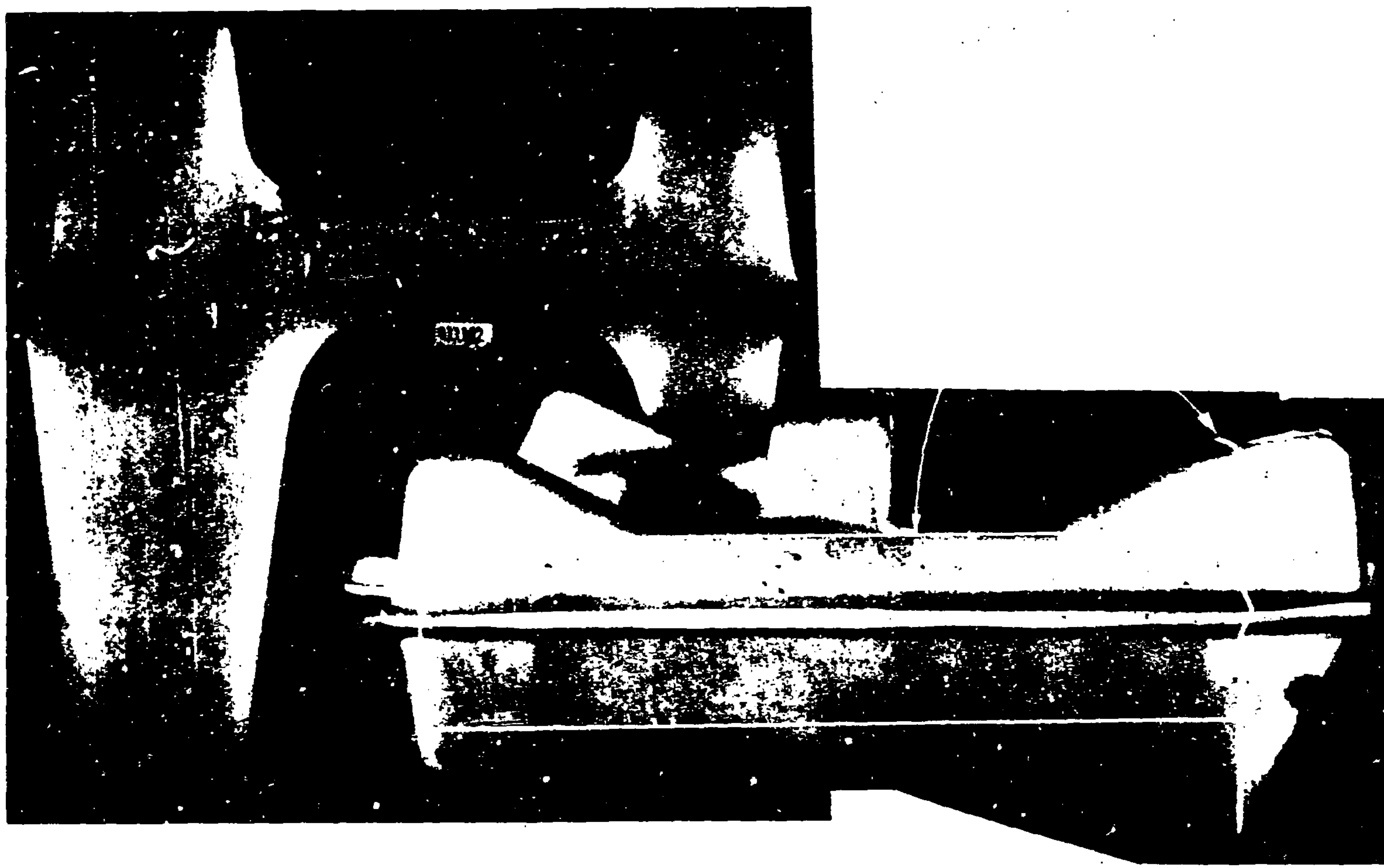


Fig. 17 Etched Cross Section of 7050-T736 Die Forging (Die No. 1364)

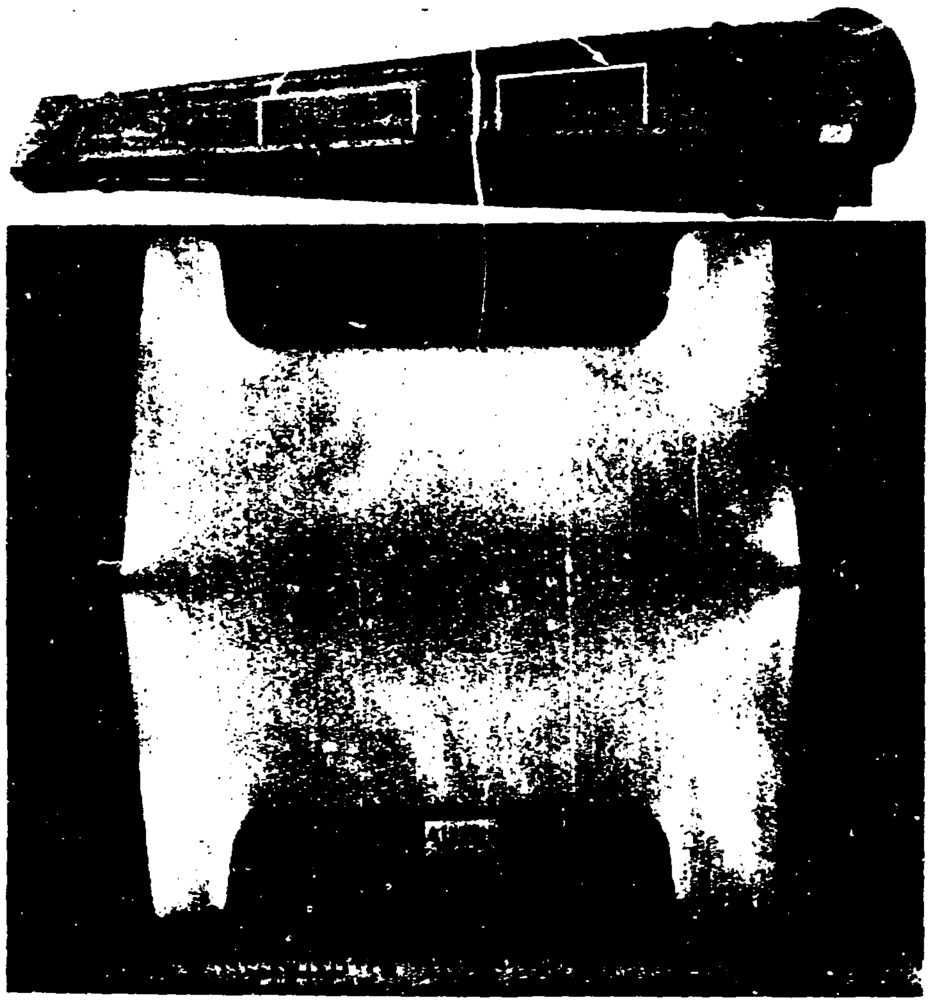


Fig. 18 Etched Cross Section of 7050-T736 Die Forging (Die No. 8457)

0001383
0008865

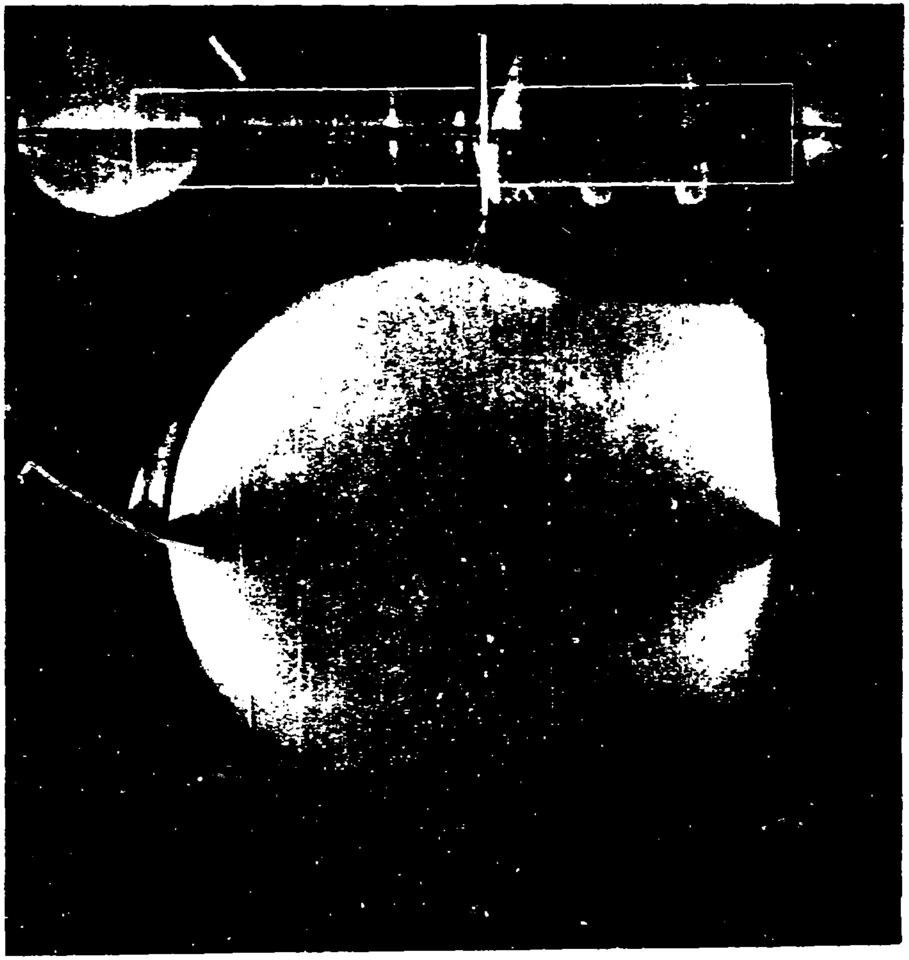


Fig. 19 Etched Cross Section of 7050-T736 Die Forging (Die No. 4736)

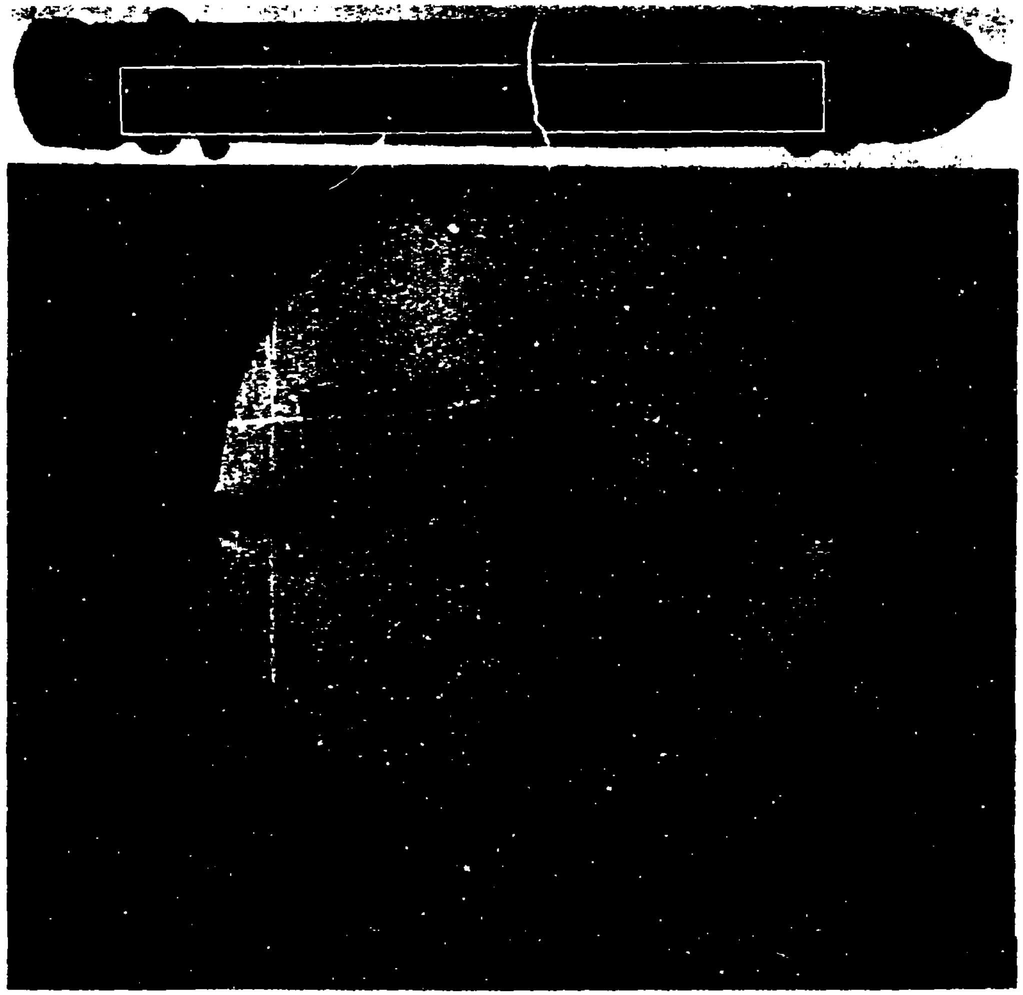
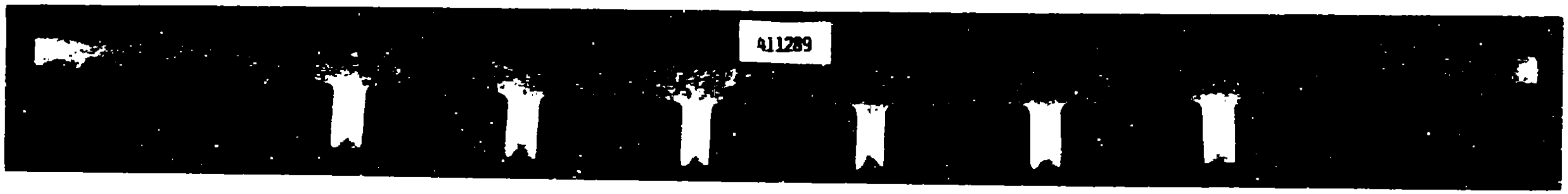


Fig. 20 Etched Cross Section of 7050-T736 Die Forging (Die No. 12767)

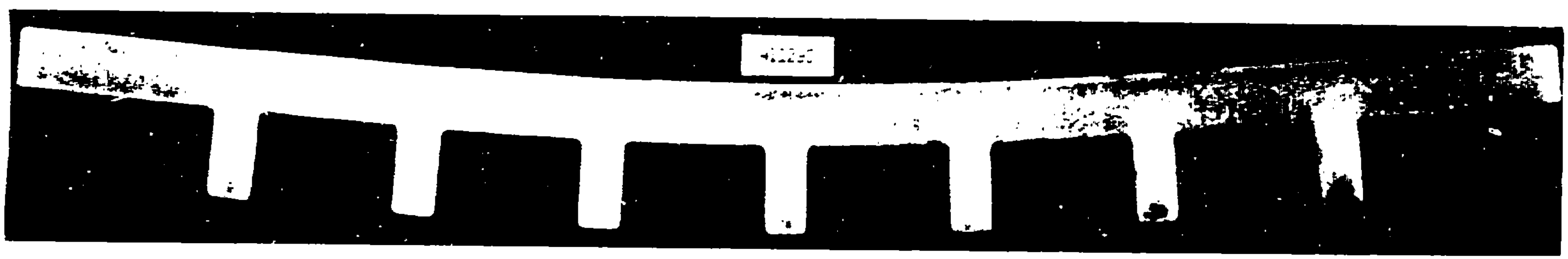
Fig. 21 Etched Cross Section of 7050-T736 Die Forging (Die No. 16392)

0008306
0008303
0008307

0.187-in. Thick x 22.56-in. Wide (Die No. 86366)



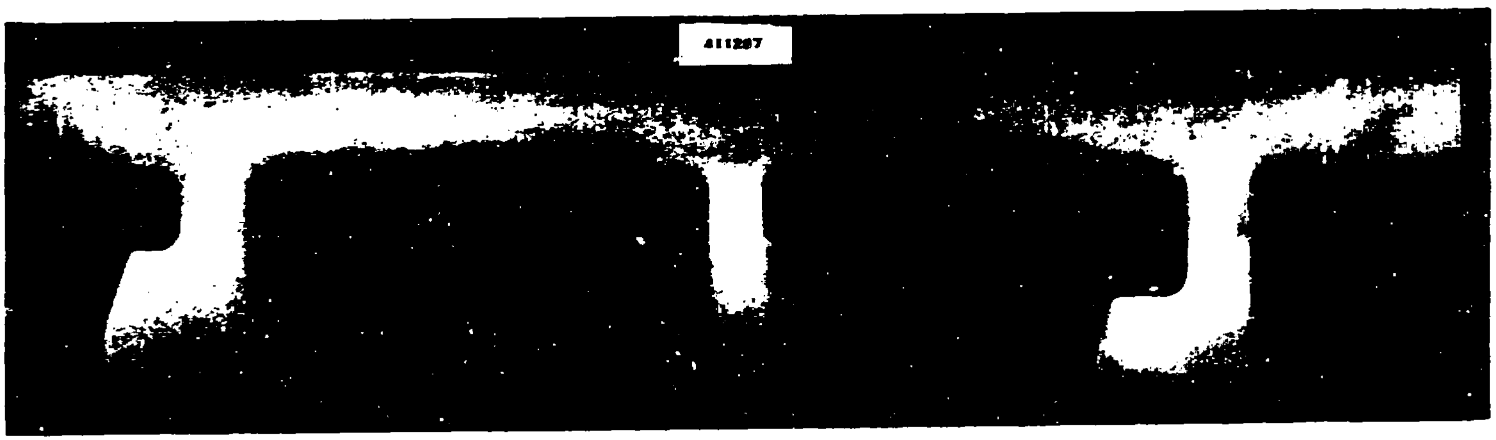
0.402-in. Thick x 16.56-in. Wide (Die No. 191282)



0.665-in. Thick x 16.9-in. Wide (Die No. 213592)

Fig. 22 Etched Cross Sections of 7050-T76511 Extruded Shapes

0.841-in. Thick x 17.18-in. Wide (Die No. 53717)

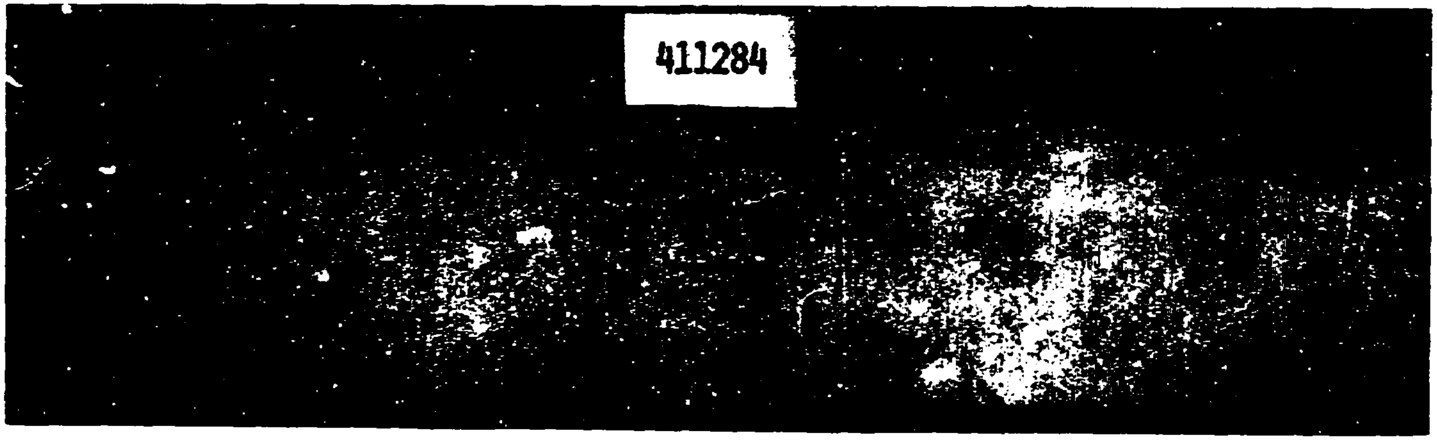


1.161-in. Thick x 17:35 in. Wide (Die No. 231372)

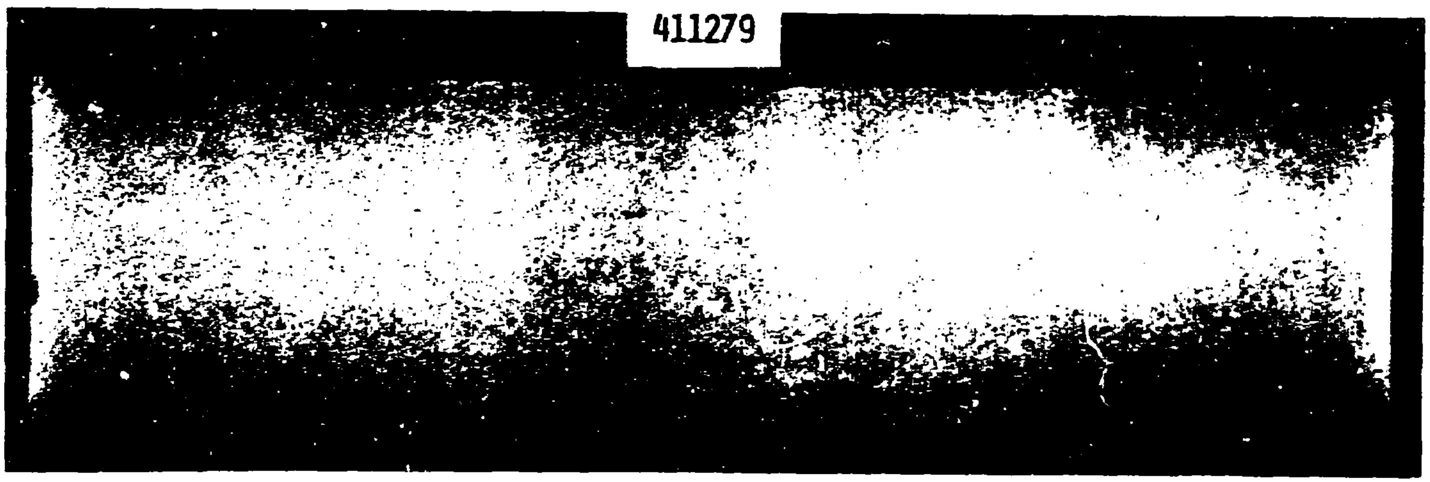
Fig. 23 Etched Cross Sections of 7050-T76511 Extruded Shapes

Fig. 23

0008308
0308309



1.5-in. Thick x.7.5-in. Wide



2-in. Thick x 8-in. Wide

Fig. 24 Etched Cross Sections of 7050-T76511 Extruded Shapes

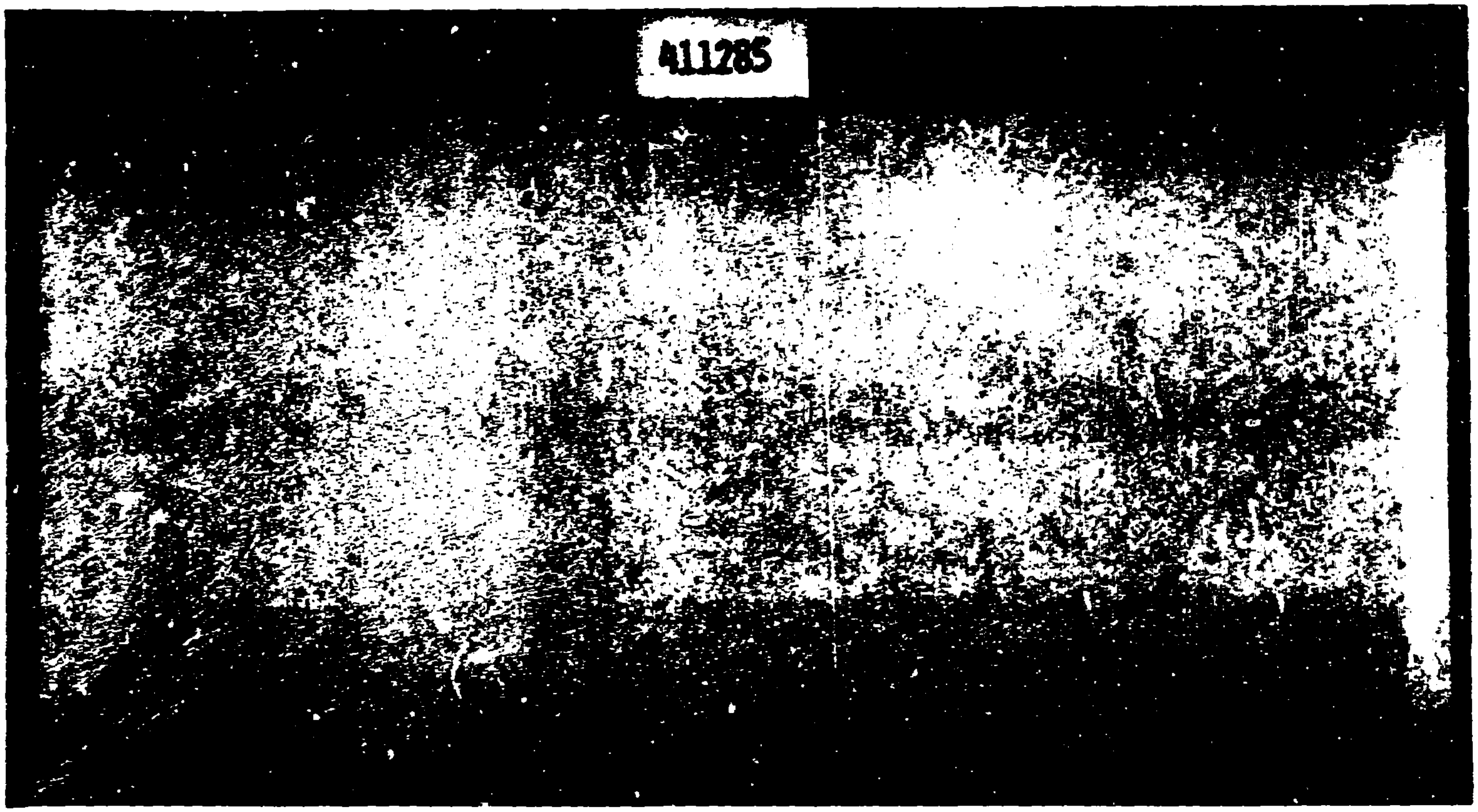


Fig. 25 Etched Cross Section of 7050-T76511 Extruded Rectangle, 3.5 x 7.5 in.

0008311

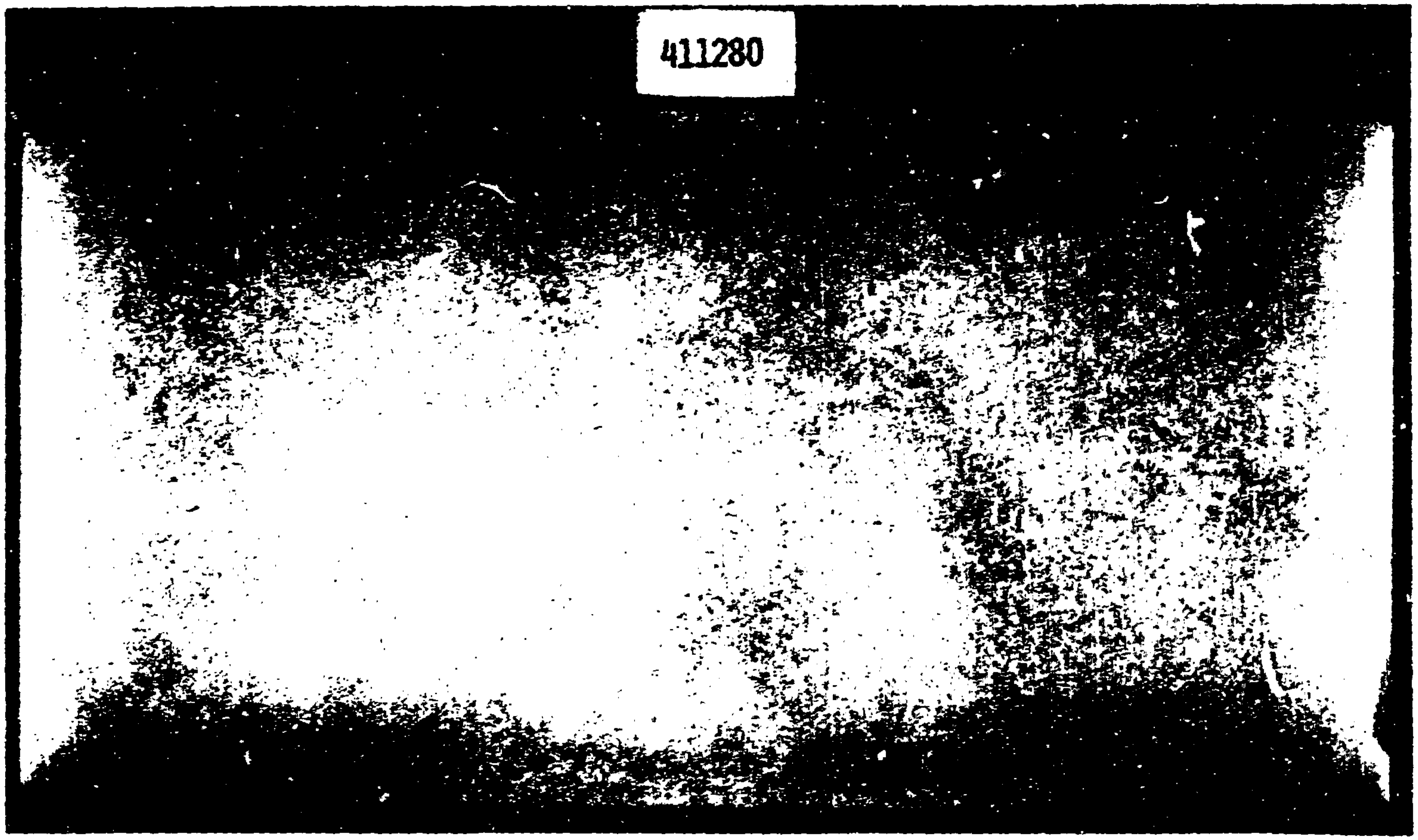


Fig. 26 Etched Cross Section of 7050-T76511 Extruded Rectangle, 4.0 x 8.0 in.

Fig. 26

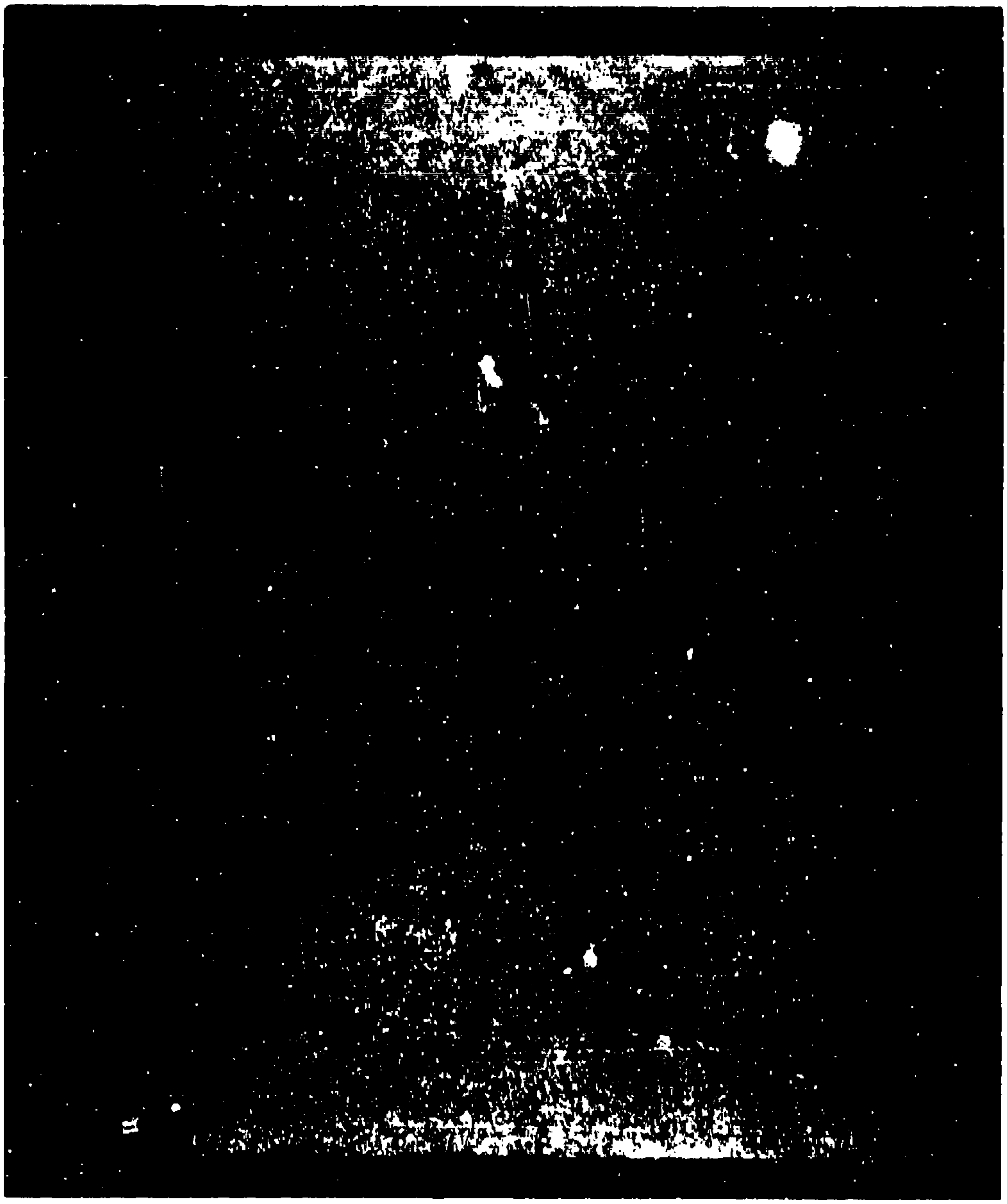
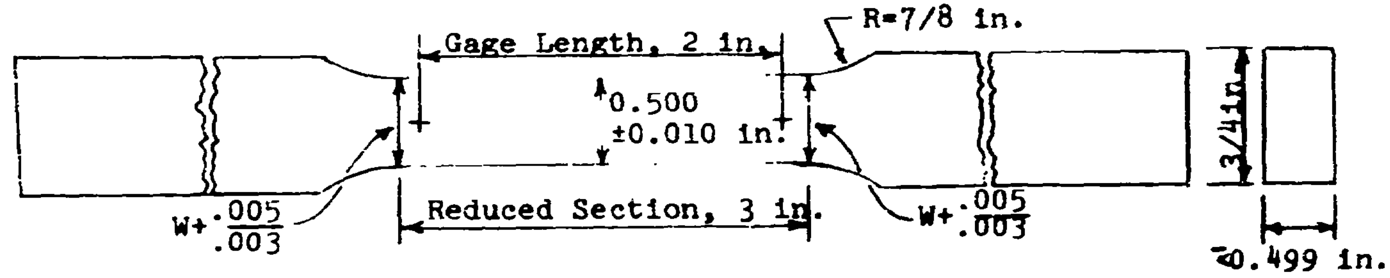
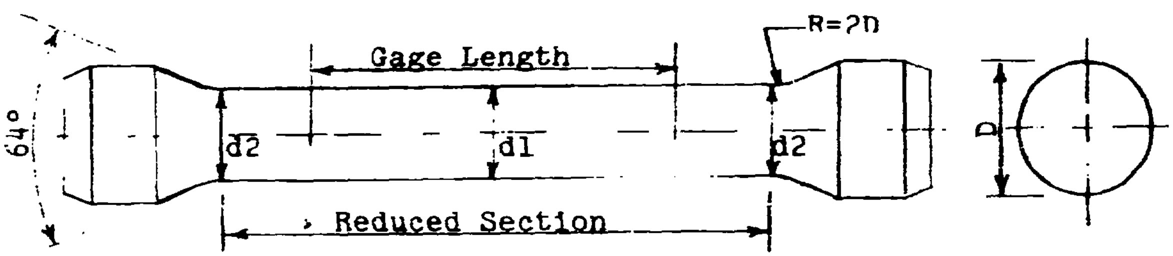


Fig. 27 Etched Cross Section of 7050-T76511 Extruded Rectangle, 5.0 x 6.25 in.

Fig. 27



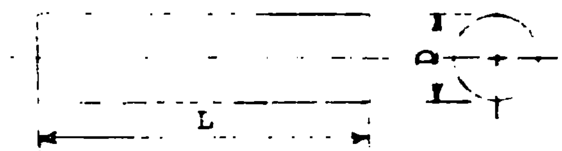
SHEET-TYPE SPECIMEN



Diameter, in. d1	Diameter, in. d2	Gage Length, in.	Reduced-Section Length, in.	Diameter, (D) in.
0.500±0.005	$d1+\frac{0.005}{0.003}$	2.0	3-1/8	3/4
0.357±0.004	$d1+\frac{0.004}{0.003}$	1.4	2-15/64	17/32
0.250±0.003	$d1+\frac{0.002}{0.001}$	1.0	1-9/16	3/8
0.160±0.002	$d1+\frac{0.002}{0.001}$	0.64	1	15/64
0.125±0.001	$d1+\frac{0.002}{0.001}$	0.50	25/32	3/16

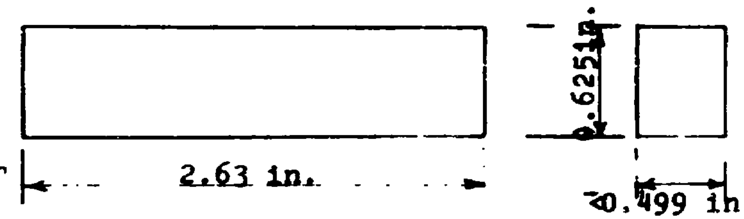
ROUND SPECIMENS

Fig. 28 General Dimensions of Tensile Specimens



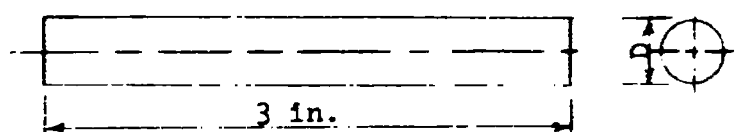
Nominal Diameter, in.	Diameter, (D) in.	Length, (L) in.
3/4*	0.7515 / 0.7485	3-1/2
1/2*	0.4980 / 0.4950	1-7/8
7/16	0.4390 / 0.4360	1-5/8
3/8	0.3765 / 0.3735	1-1/2

ROUND COMPRESSIVE SPECIMEN



SHEET-TYPE COMPRESSIVE SPECIMEN*

* Strain-gage length for specimens used in stress-strain tests: 0.062-in.

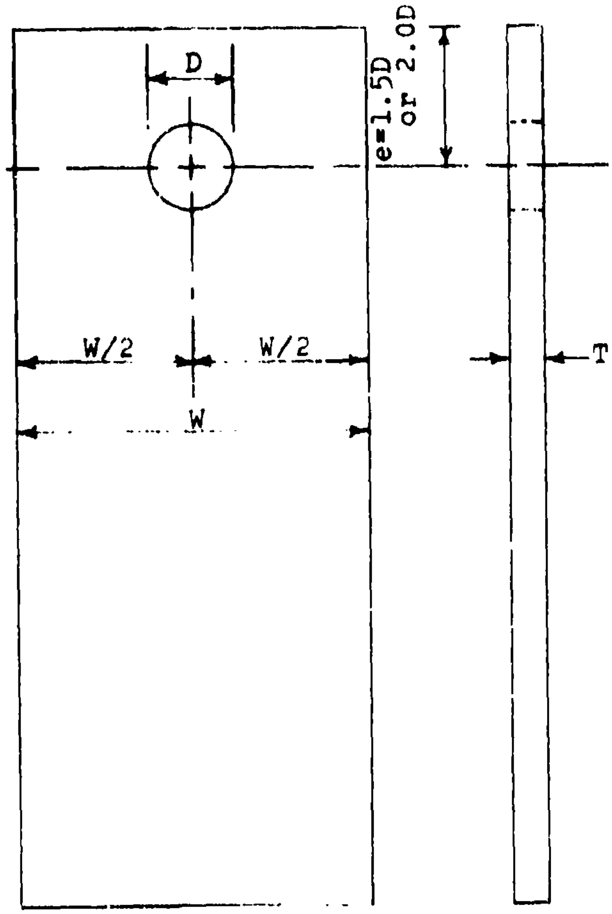


Nominal Diameter, in.	Diameter, (D) in.
3/8	0.3730 / 0.3720
1/4	0.2490 / 0.2480
3/16	0.1865 / 0.1855

ROUND SHEAR SPECIMEN

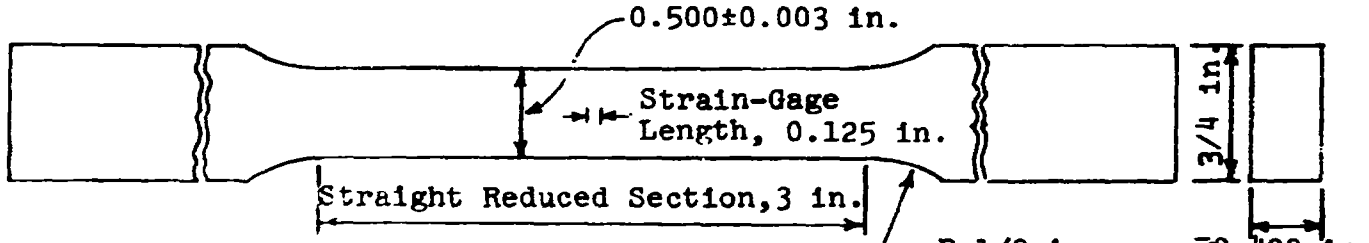
Fig. 29 General Dimensions of Compressive and Shear Specimens

Fig. 29

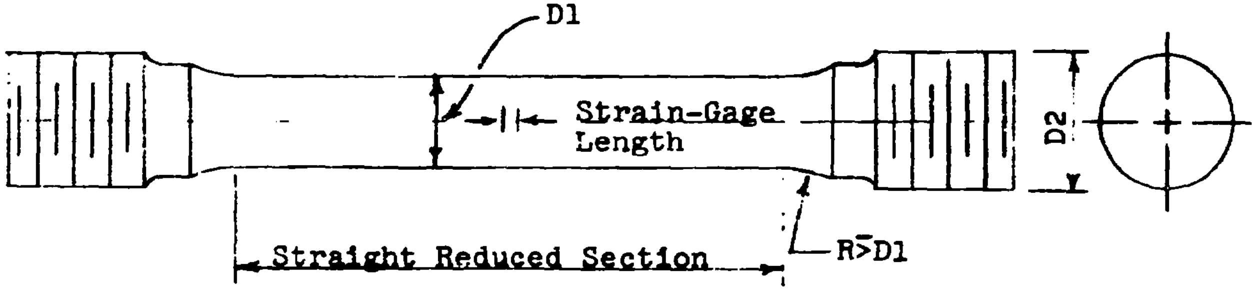


Specimen Thickness, (T) in.	Pin Hole Diameter, (D) in.	Specimen Width, (W) in.
0.125to0.249	0.500	2.0
0.090to0.094	0.375	1.5
0.063	0.250	1.5
0.040	0.160	1.0

Fig. 30 General Dimensions of Bearing Specimens



SHEET-TYPE SPECIMEN



Diameter, in.		Strain-Gage Length, in.	Reduced-Section Length, in.
D1	D2		
0.500±0.003	3/4	0.062, 0.125	3
0.438±0.003	5/8	0.062	2-7/8
0.438±0.003	5/8	0.062	1-7/8
0.375±0.003	9/16	0.062	2-3/4
0.357±0.003	9/16	0.062	2-3/4
0.312±0.002	1/2	0.062	1-5/8

ROUND SPECIMENS

Fig. 31 General Dimensions of Tensile Specimens For Modulus and Stress-Strain Tests

Fig. 31

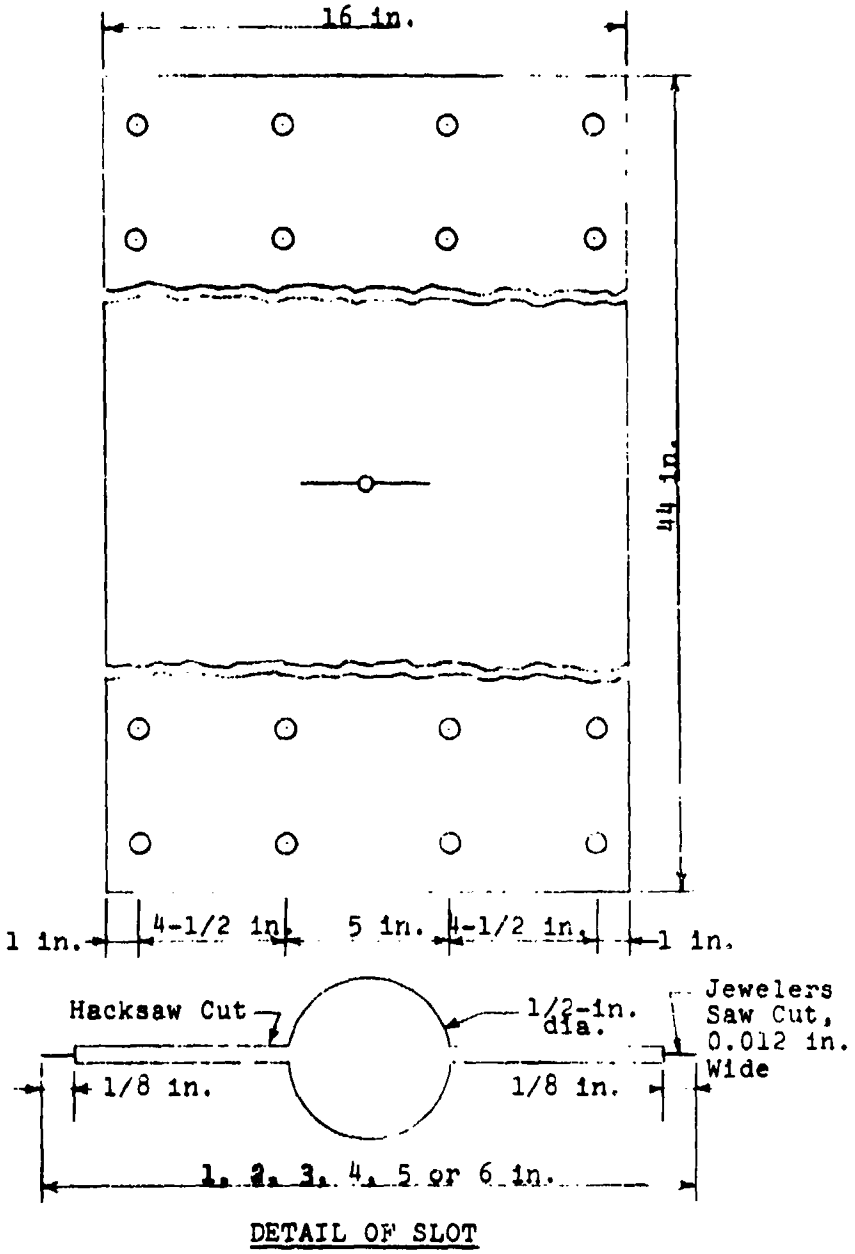


Fig. 32 General Dimensions of Center-Slotted Fracture Toughness Panels

Fig. 32

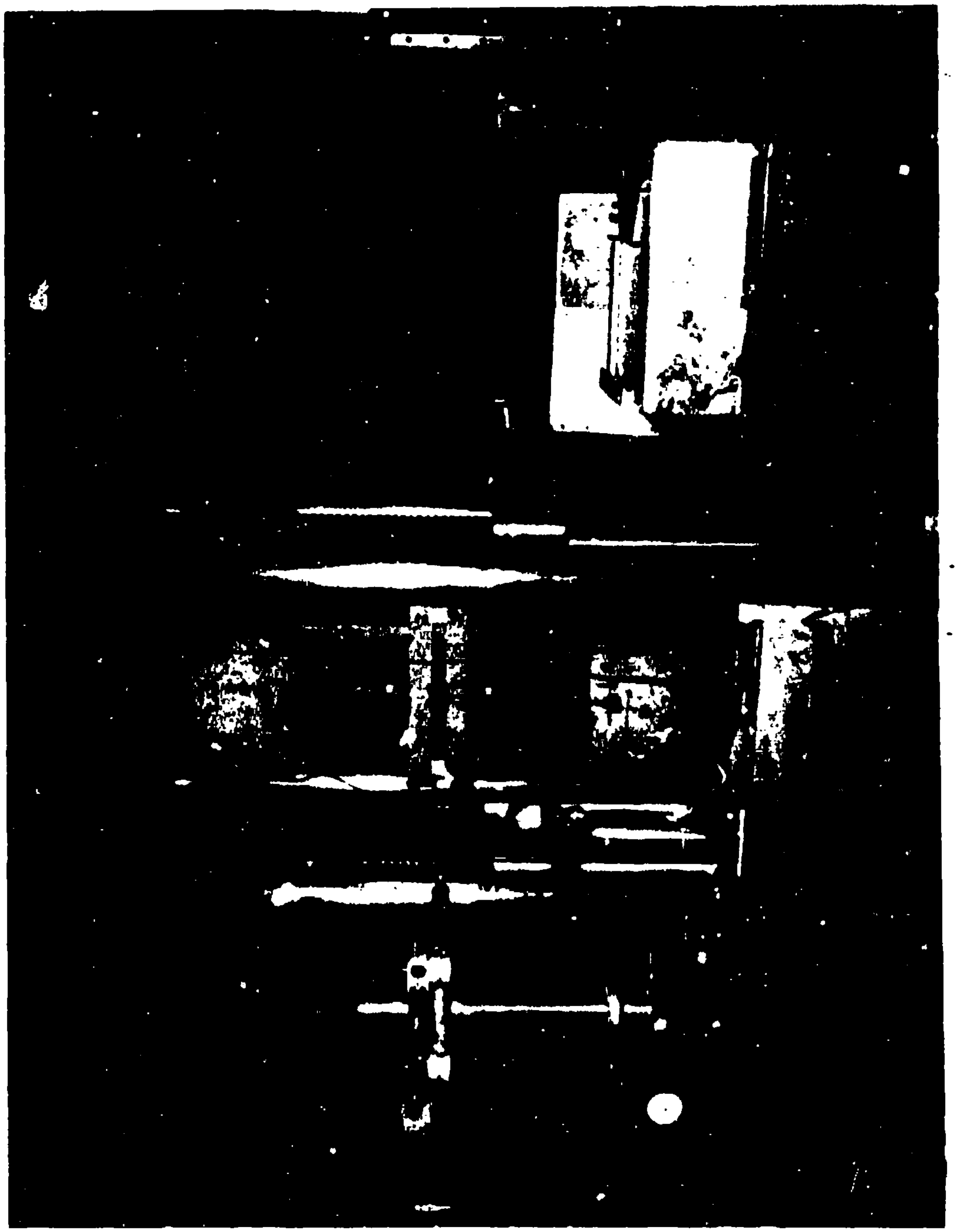
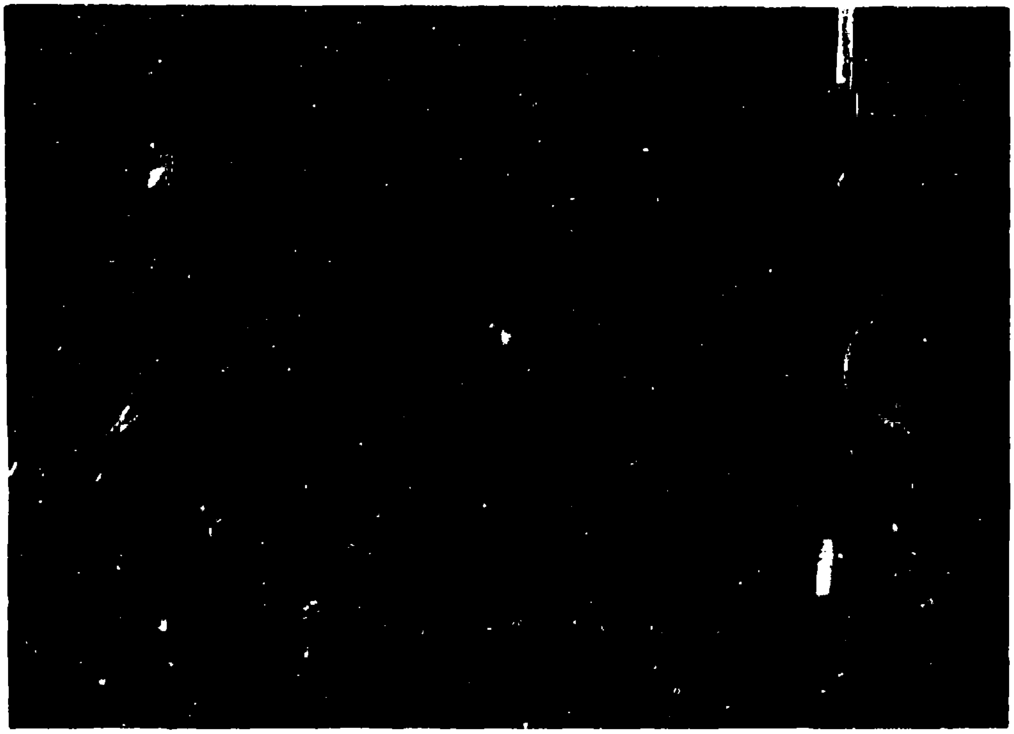


Fig. 33 Setup for Testing 16-in. Wide Center-Slot Fracture Toughness Specimens

Fig. 33



Anti-buckling Guide and Strain Gages

Improved Anti-Buckling Guide

Fig. 34 Setups for Testing 16-in. Wide Center-Slot Fracture Toughness Specimens With Anti-buckling Guides.

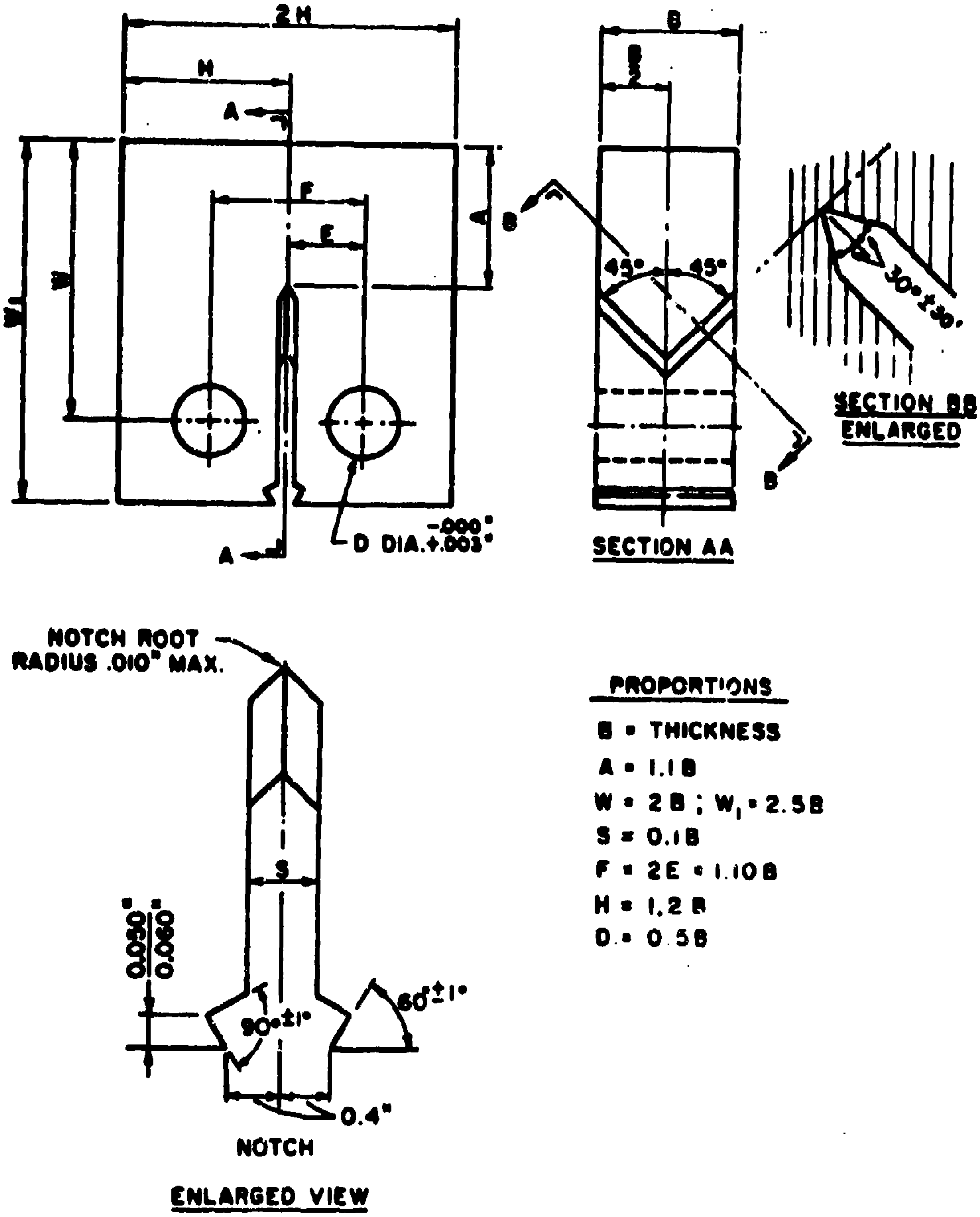


Fig. 35 COMPACT TENSION FRACTURE TOUGHNESS SPECIMEN

Fig. 35

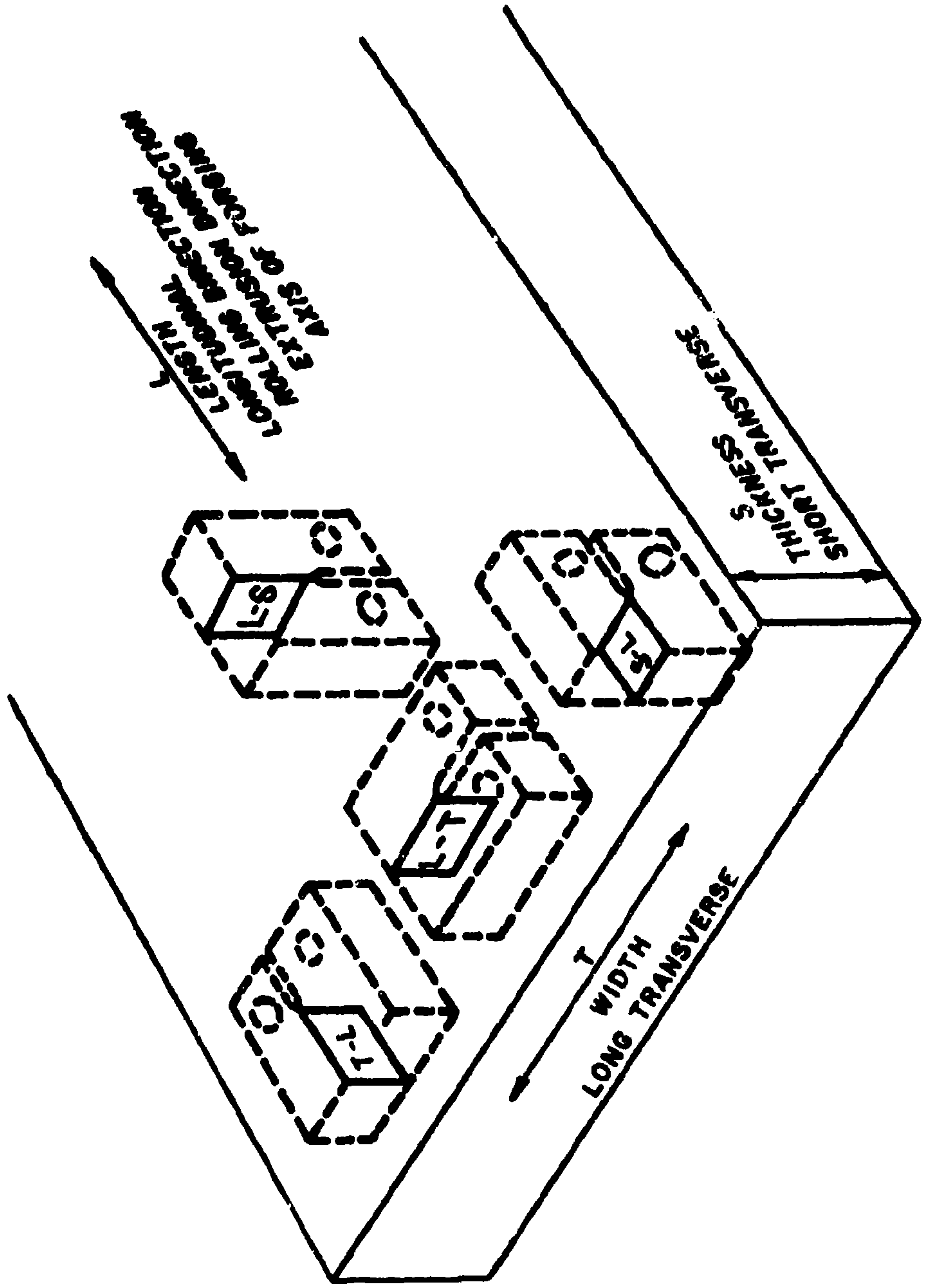


Fig. 36 FRACTURE-TOUGHNESS SPECIMEN ORIENTATIONS

Fig. 36

Fig. 37 Setup for Fatigue Precracking of
Compact Tension Fracture Toughness Specimens

7113821

Fig. 37

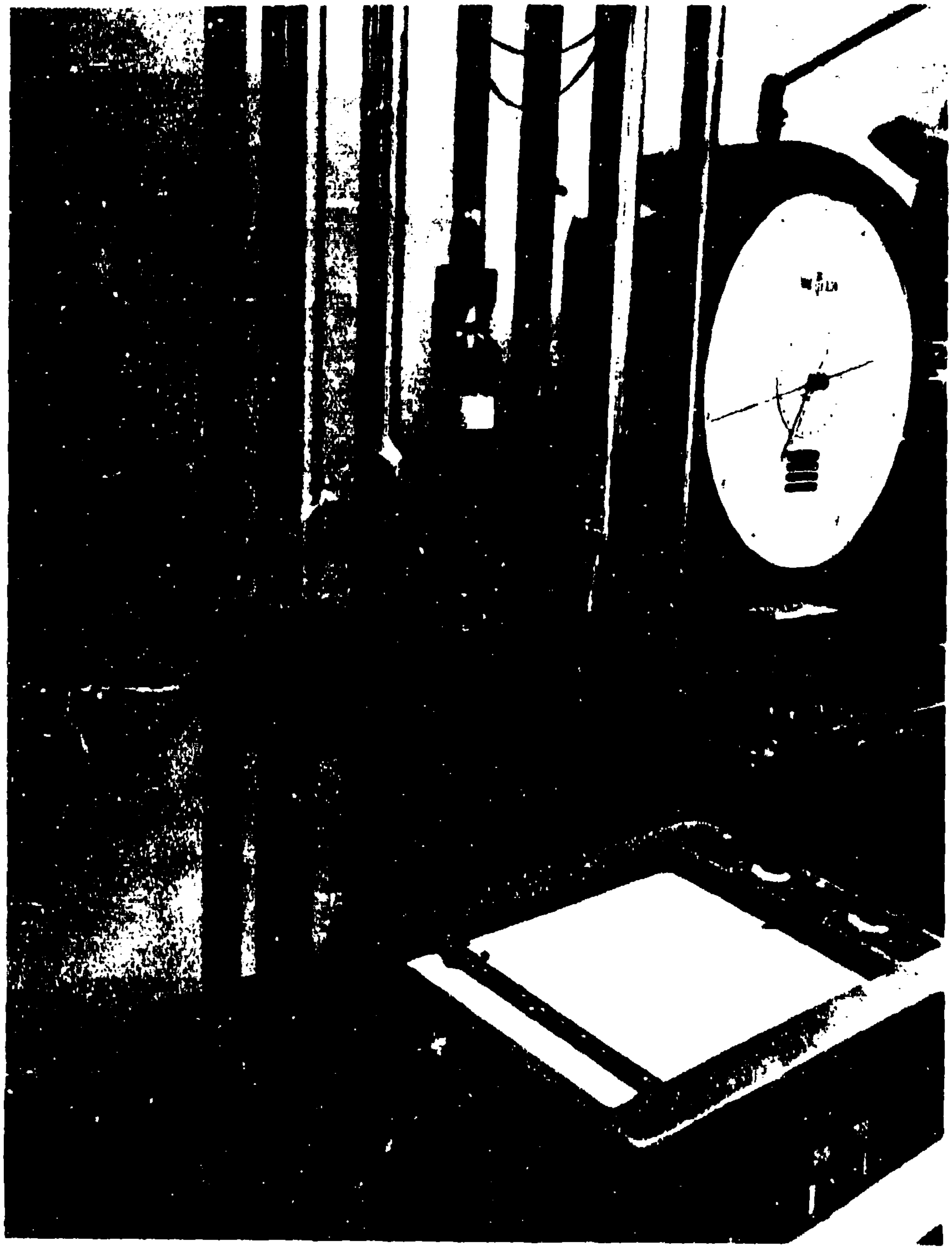
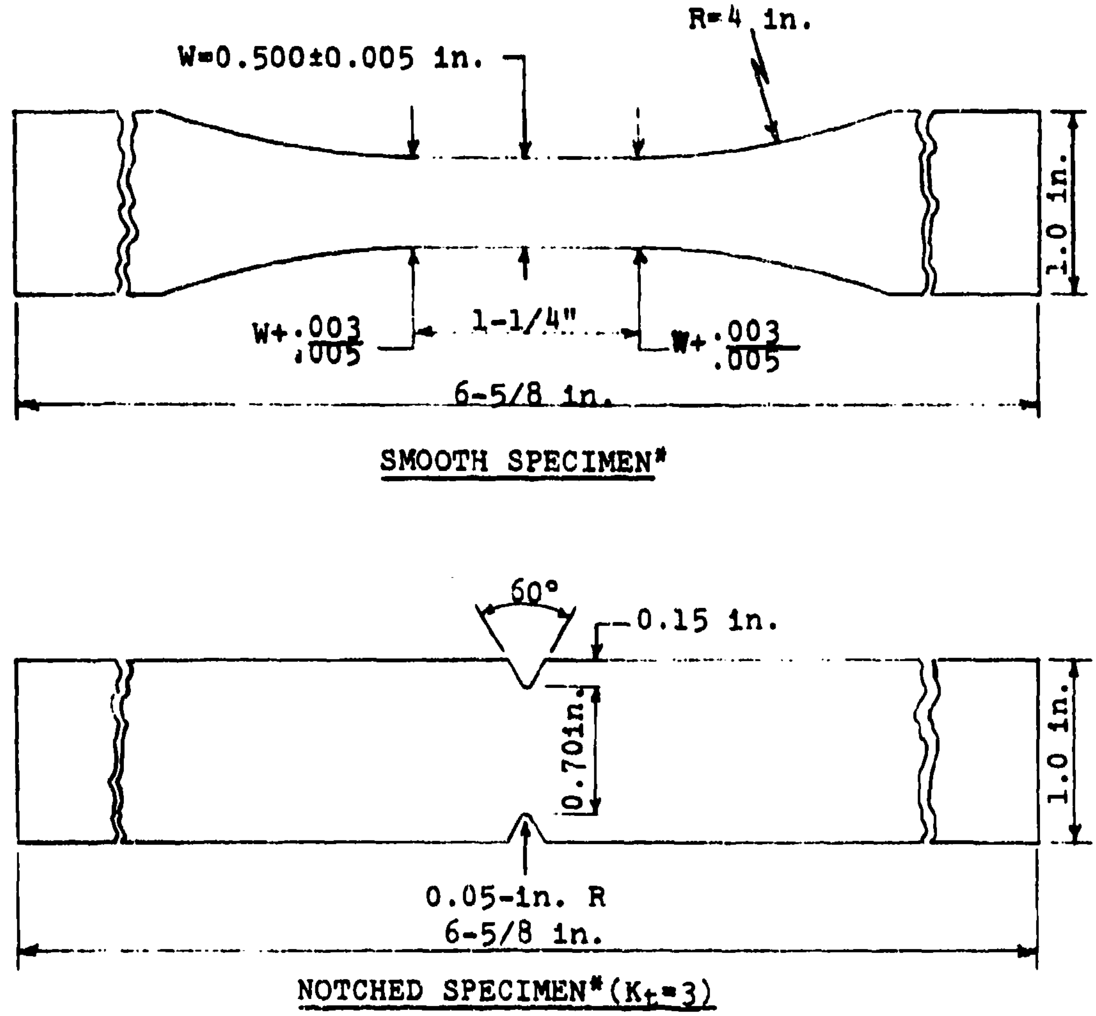


Fig. 38 Setup for Testing Compact Tension Fracture Toughness Specimens

PGD083

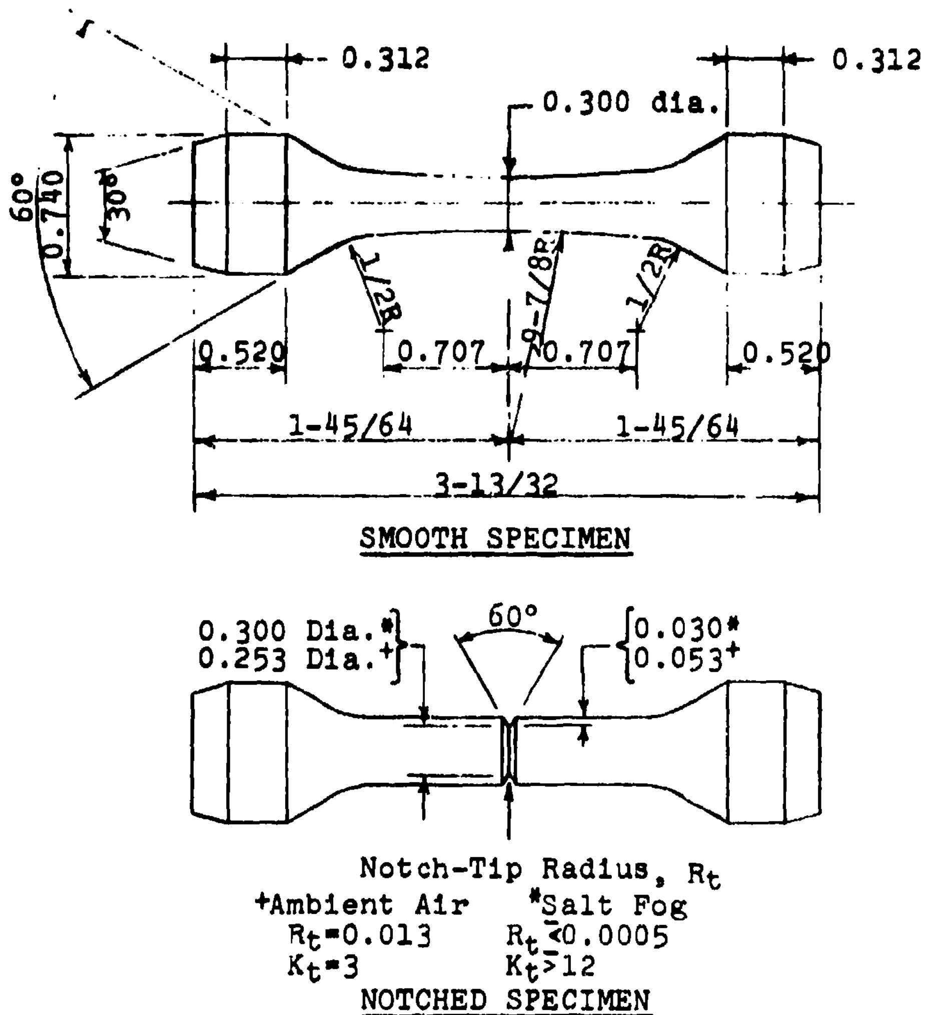
Fig. 38



* Thickness ≤ 0.125 in.

Fig. 39 General Dimensions of Smooth and Notched Sheet-Type Axial-Stress Fatigue Specimens

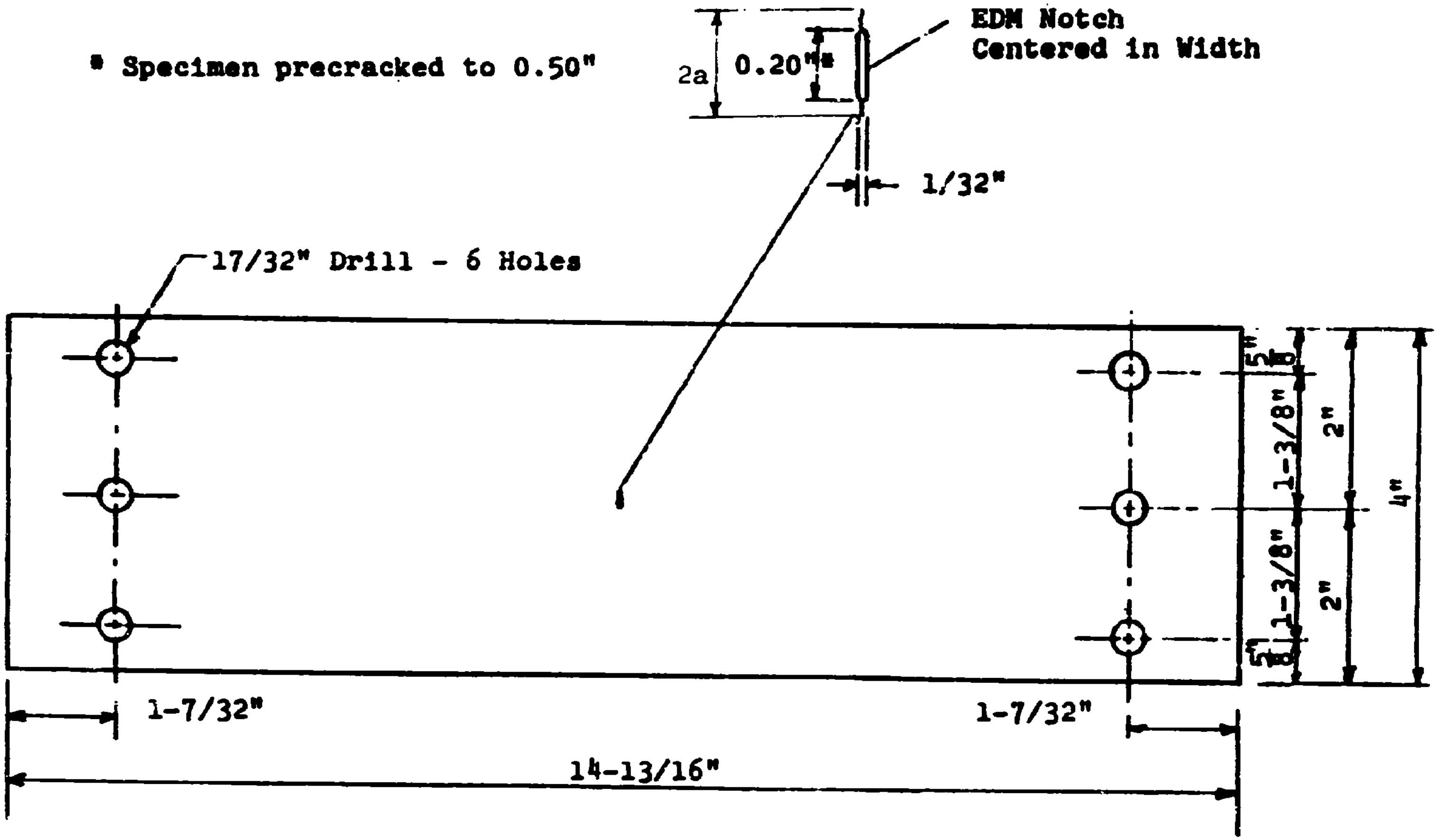
Fig. 39



Note: All dimensions in inches

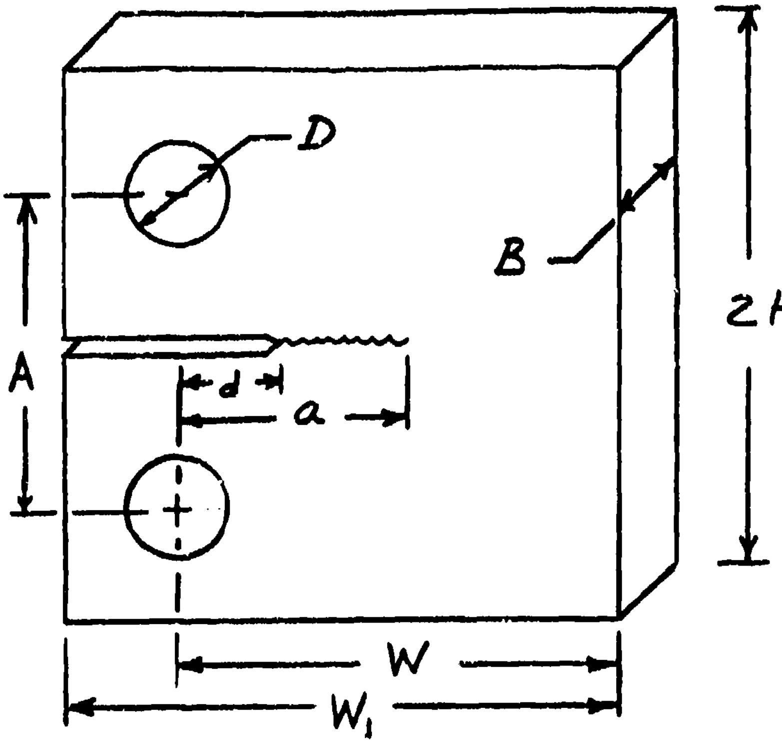
Fig. 40 Dimensions of Smooth and Notched Axial-Stress Fatigue Specimens

Fig. 40



B=full thickness of sheet.

Fig. 41 Crack Propagation Specimen for Sheet



a = crack length

Special Dimensions - Inches

B	2H	W	A	D	d	W_1	H/W
1.00	3.72	3.805	1.650	0.75	1.151	4.80	0.485
1.00	3.72	3.100	1.650	0.75	1.151	4.10	0.6

Fig. 42 Dimensions for Compact Tension Fatigue Crack-Propagation Specimen

Fig. 42

Fig. 43 Environmental Chamber for Fatigue-Crack Propagation Tests of Sheet.

Fig. 43

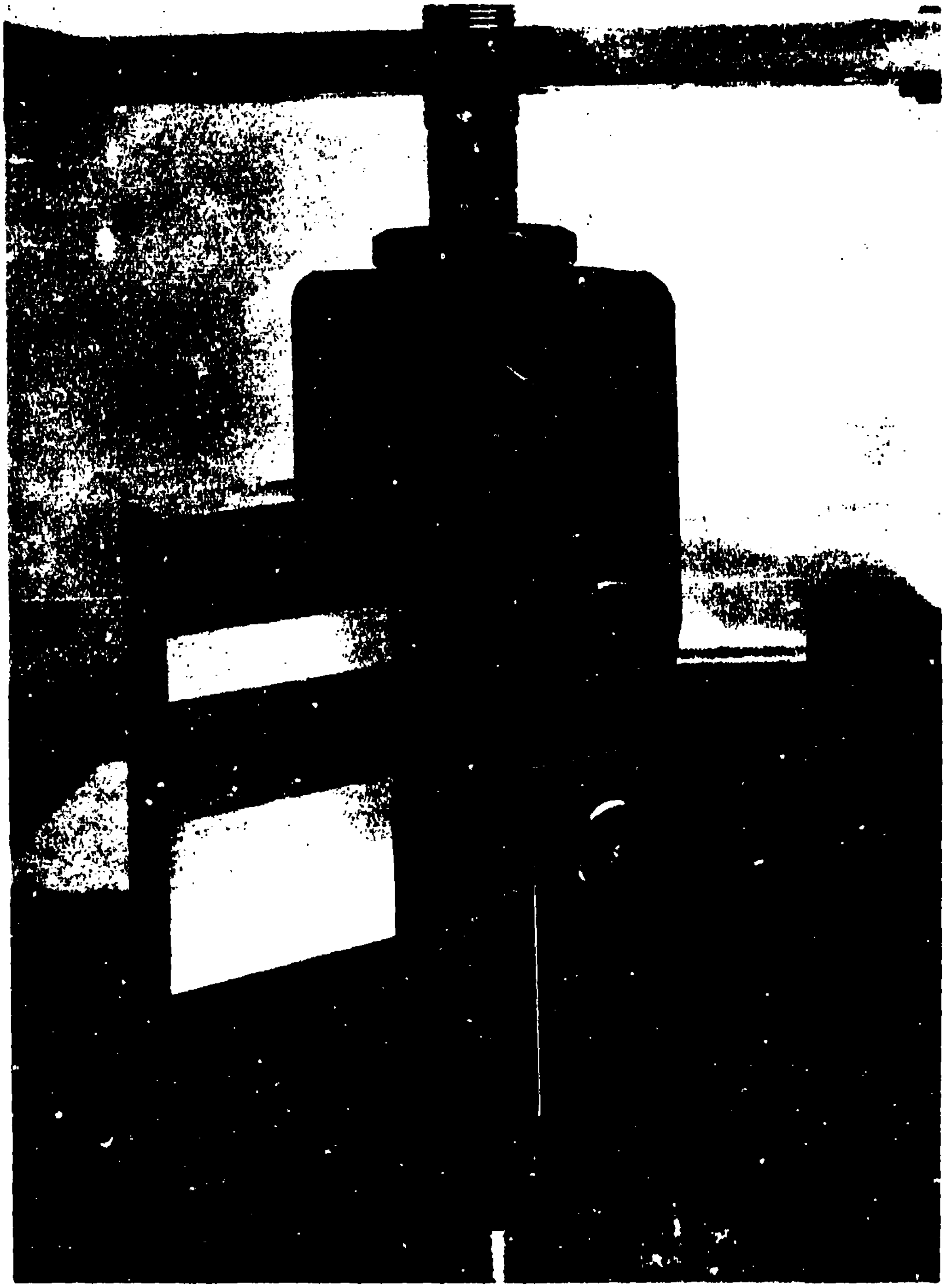


Fig. 44 Compact Tension Crack Propagation Specimen in Fatigue Machine

7112061

Fig. 44

7206123

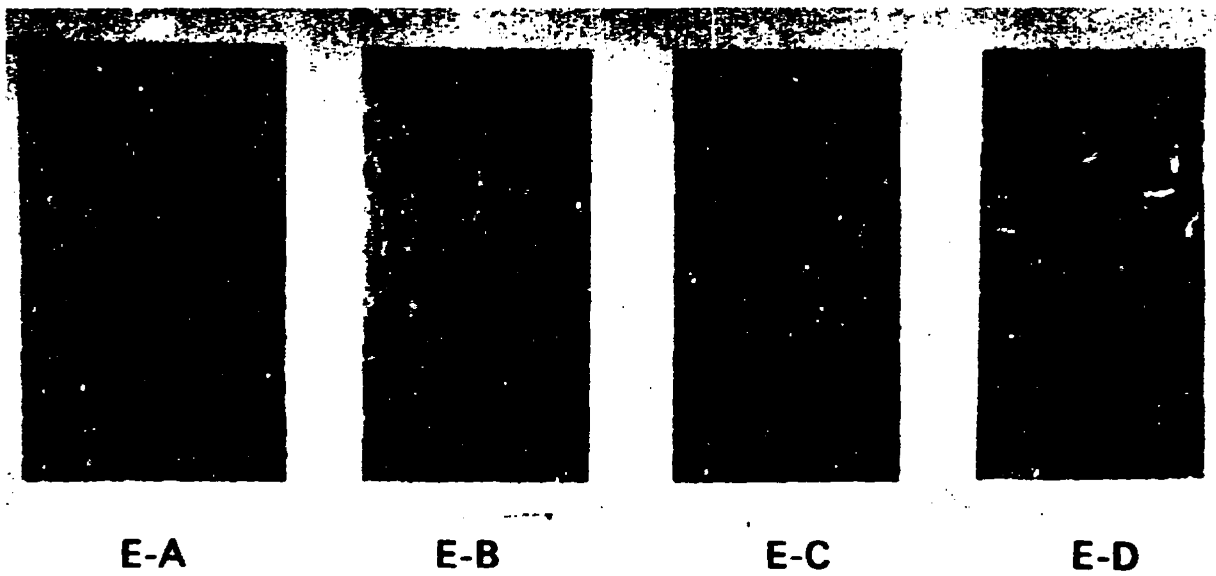


Fig. 45 - Four Degrees of Severity of Exfoliation Corrosion Per ASTM Standard Method Test G34-72.

Fig. 45

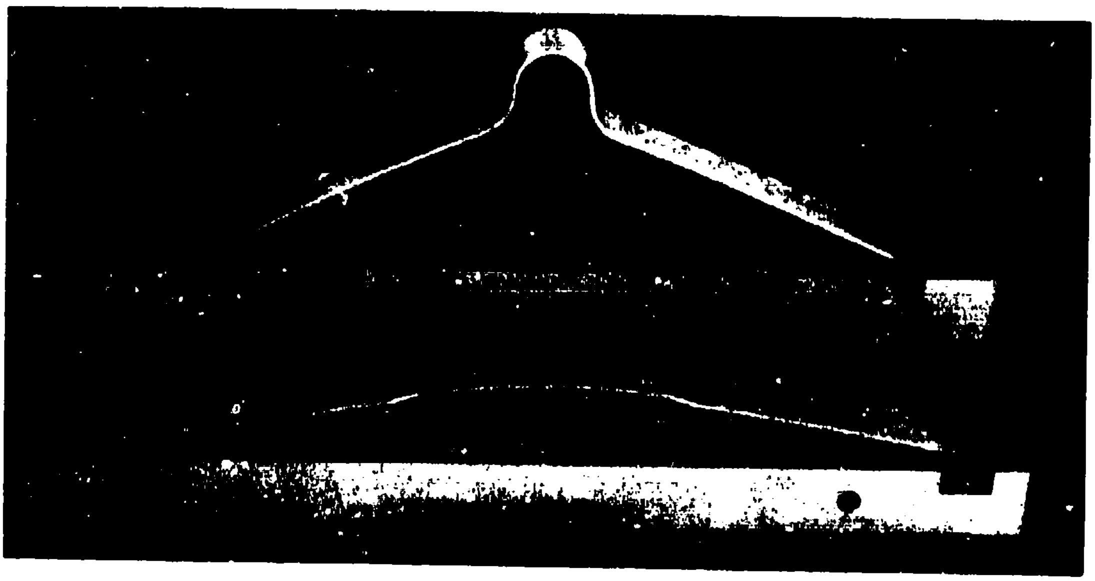
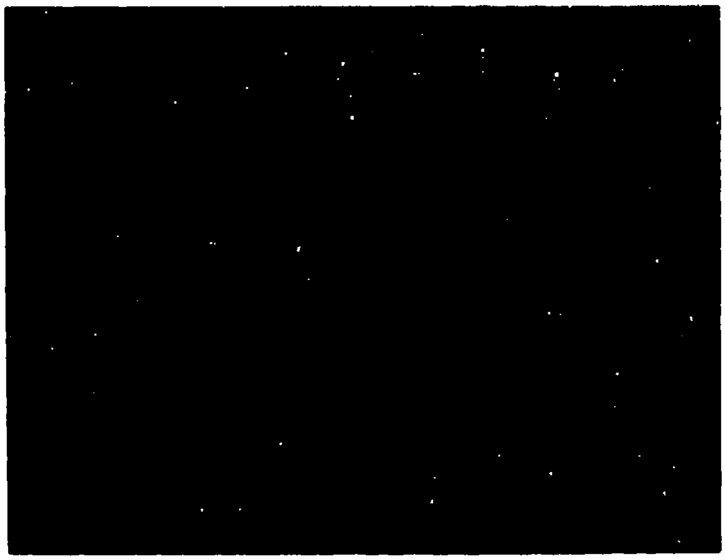


Fig. 46 - Preformed Blank and Sheet Tensile Specimen End Loaded For Corrosion Tests.



Mag: 1/2X

Fig. 47a 1/8-in. Diameter Tensile Specimen, Various Parts of the Stressing Frame and Final Stressed Assembly for Stress Corrosion Tests.

Mag: 1/5X

Fig. 47b Synchronous Loading Device Used to Stress Specimens. Stressed Assembly and One Assembled Finger Tight Ready For Stressing Are Shown to the Left.

Fig. 47a

Fig. 47b

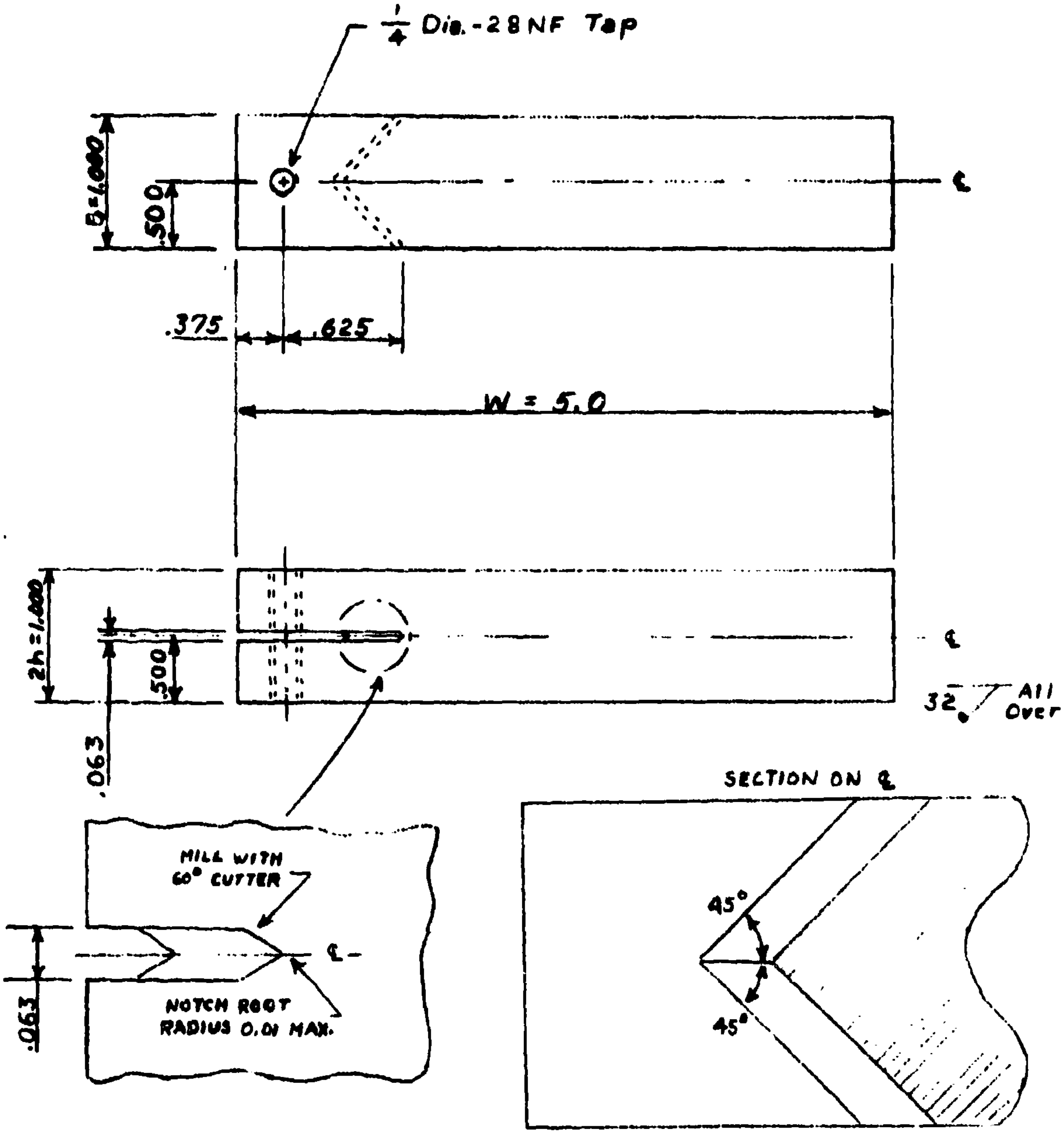


Fig. 48 Configuration of Double Cantilever Beam (DCB) Specimen Used for SCC Tests

Fig. 48

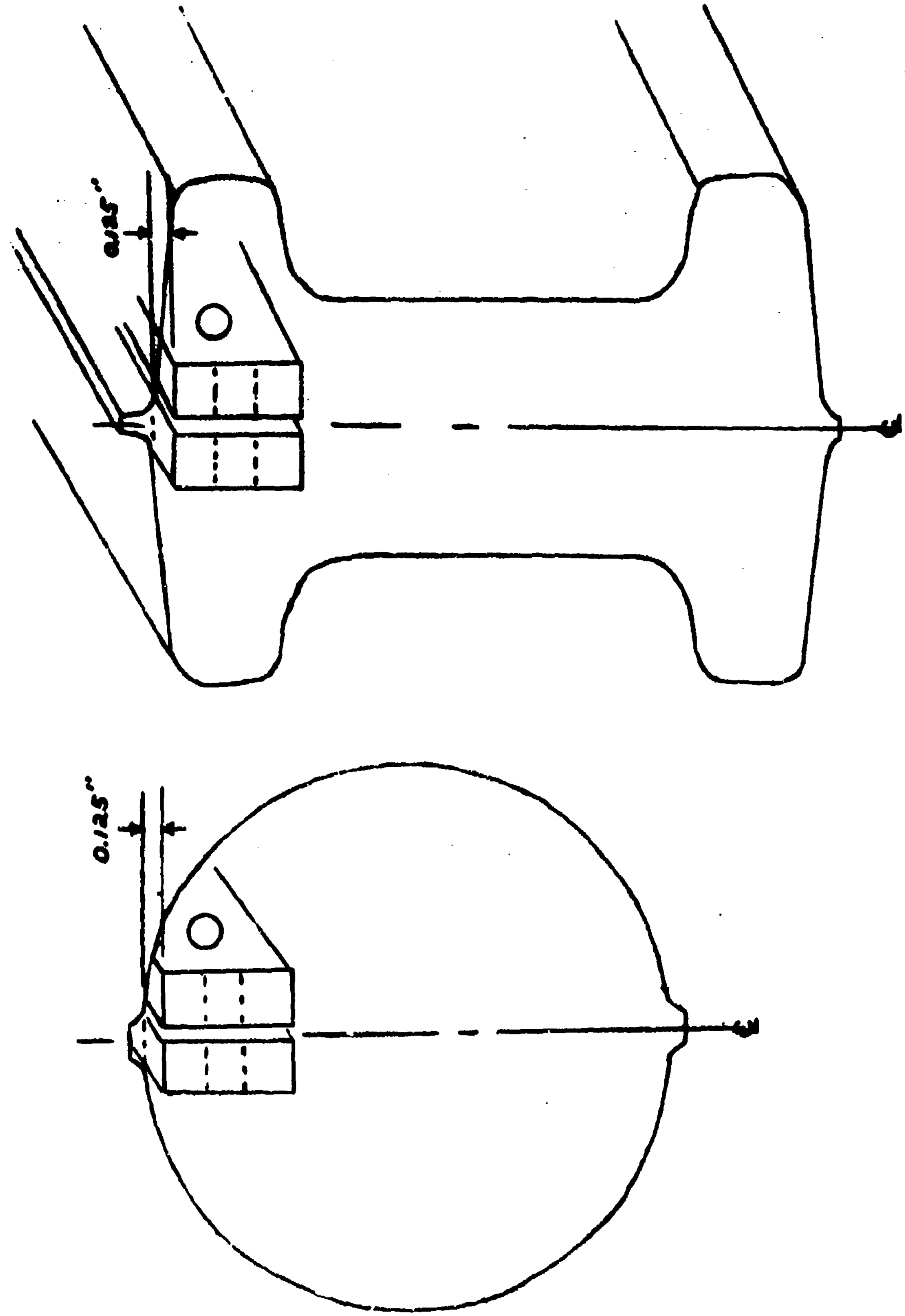


Fig. 49 Sketches Showing Location of DCB Specimens Used for SCC Tests of Die Forgings

Fig. 49

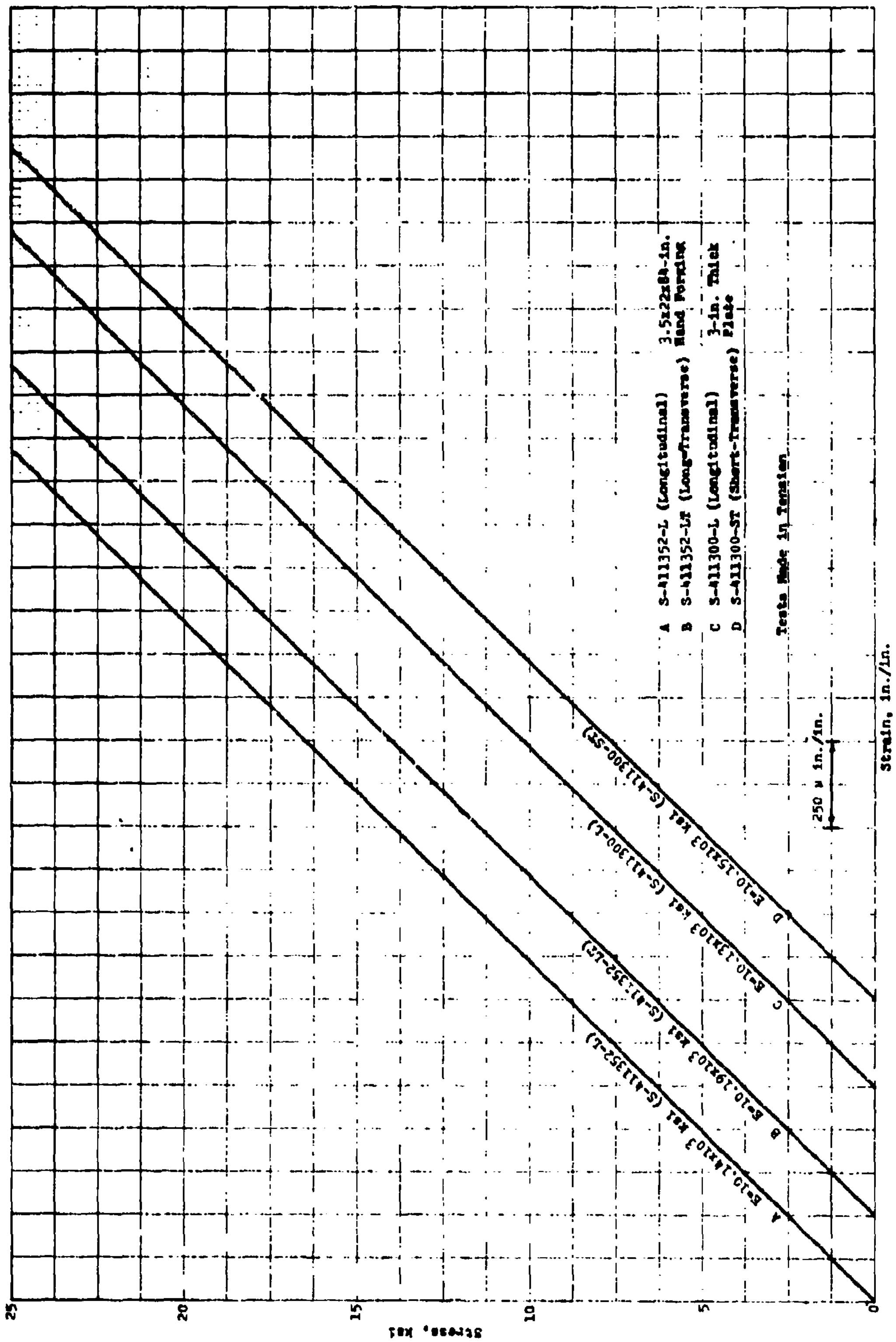


Fig. 50 Representative Stress-Strain Plots Obtained with an X-Y Recorder For Determining Modulus of Elasticity

Fig. 50

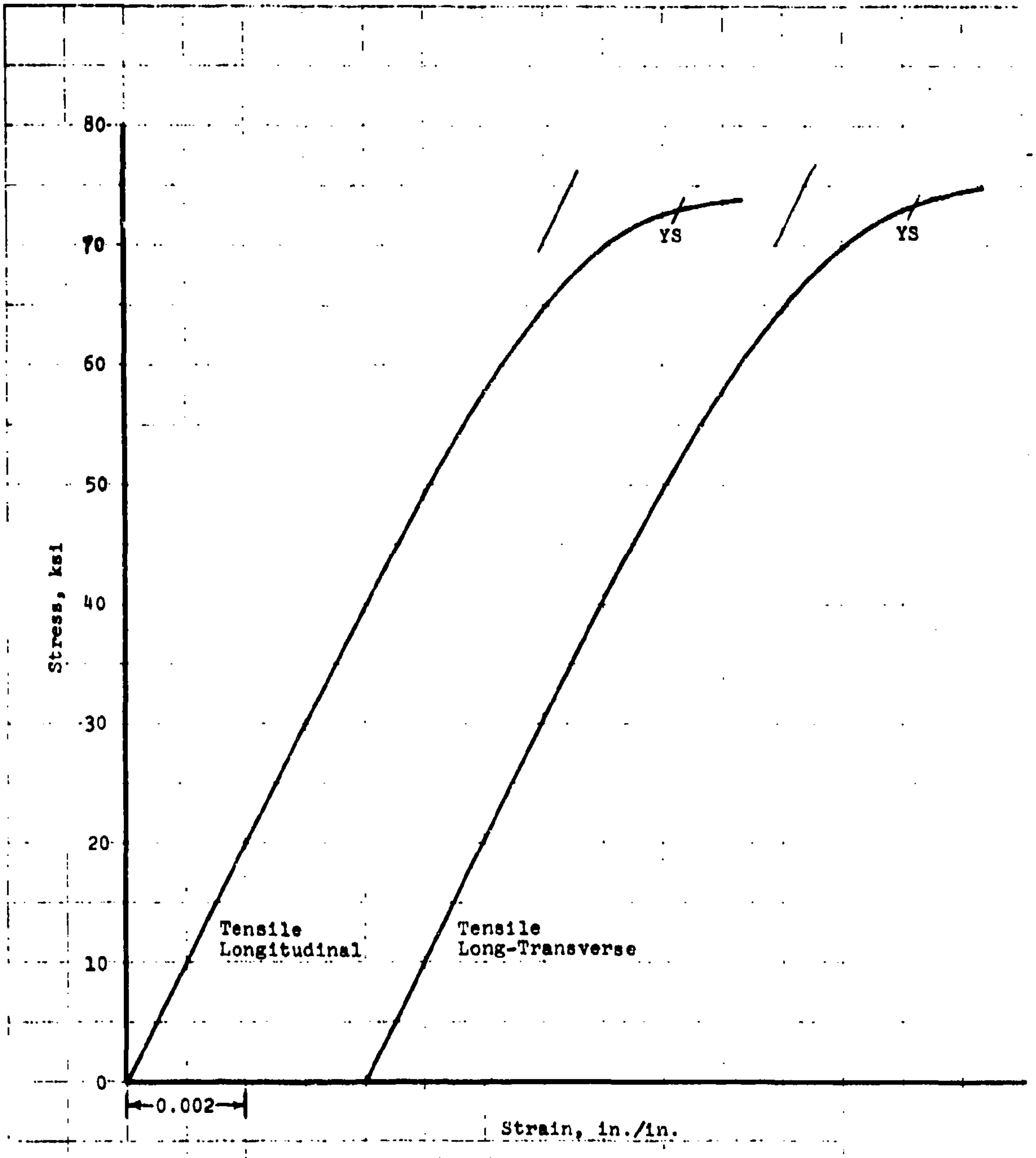


Fig. 51 Tensile Stress-Strain Curves for 0.040-in. Thick 7050-T76 Sheet (S-428882)

Fig. 51

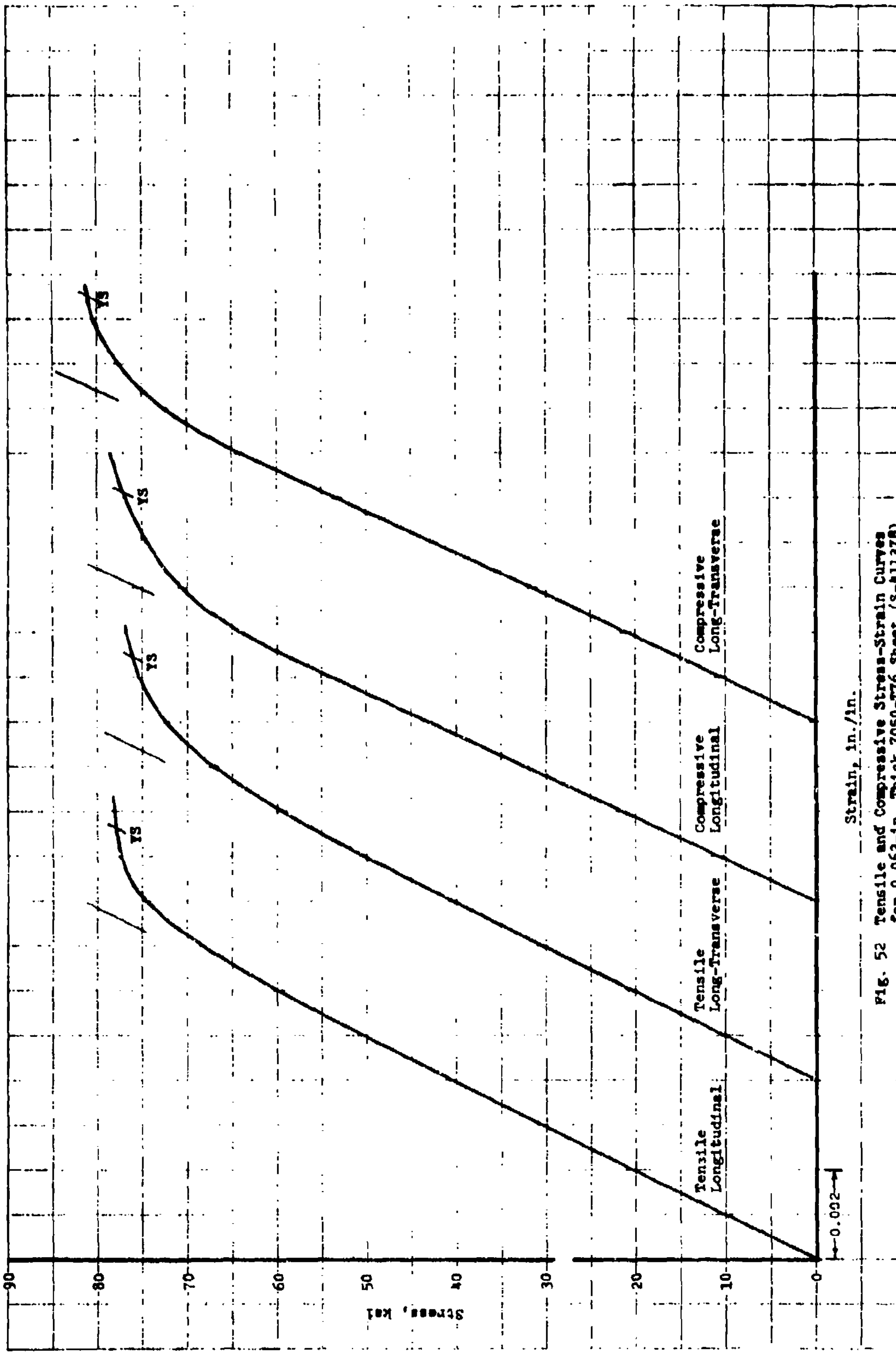


Fig. 52 Tensile and Compressive Stress-Strain Curves for 0.063-in. Thick 7050-T76 Sheet (S-411378)

Fig. 52

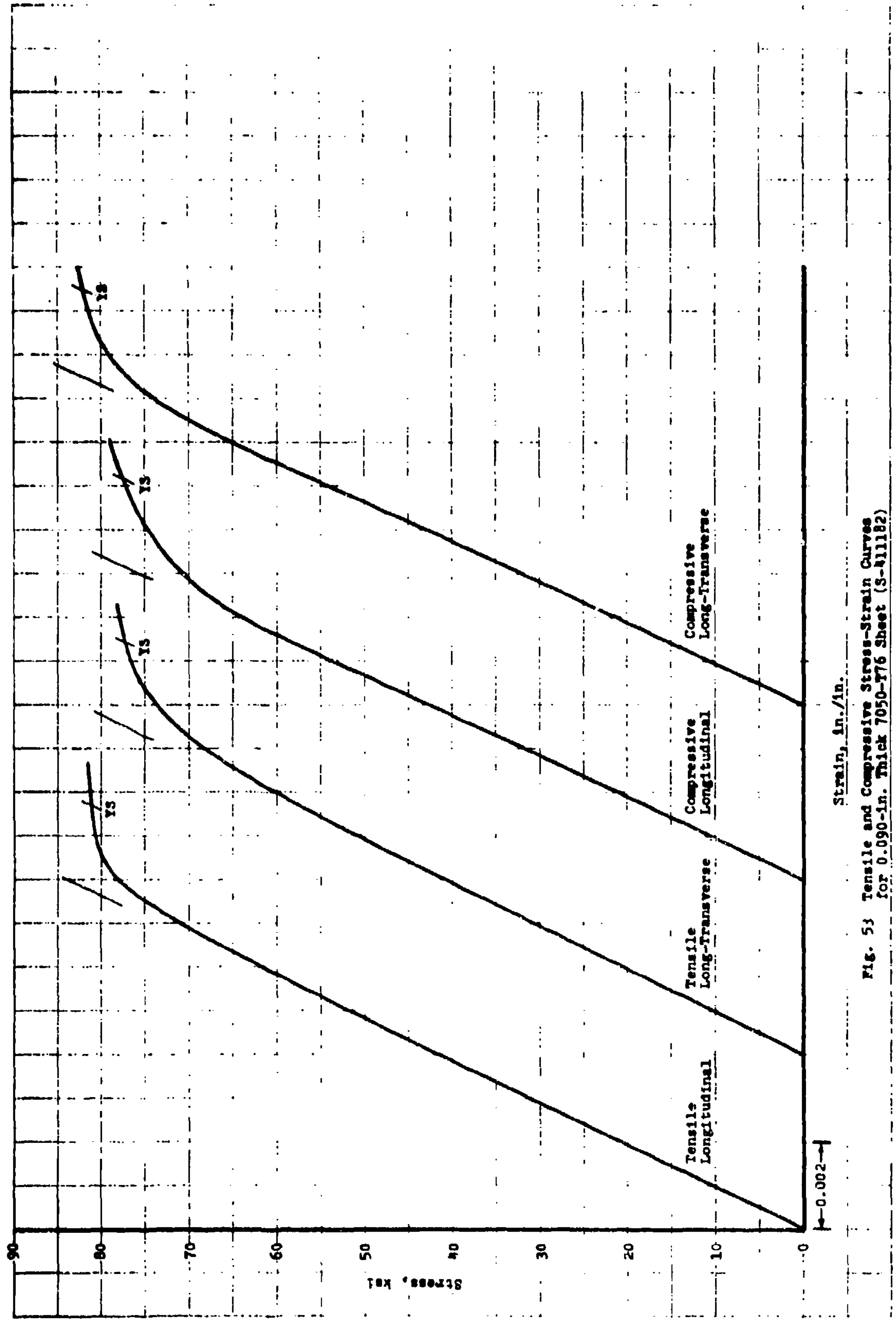


Fig. 53 Tensile and Compressive Stress-Strain Curves for 0.090-in. Thick 7050-T76 Sheet (S-411182)

Fig. 53

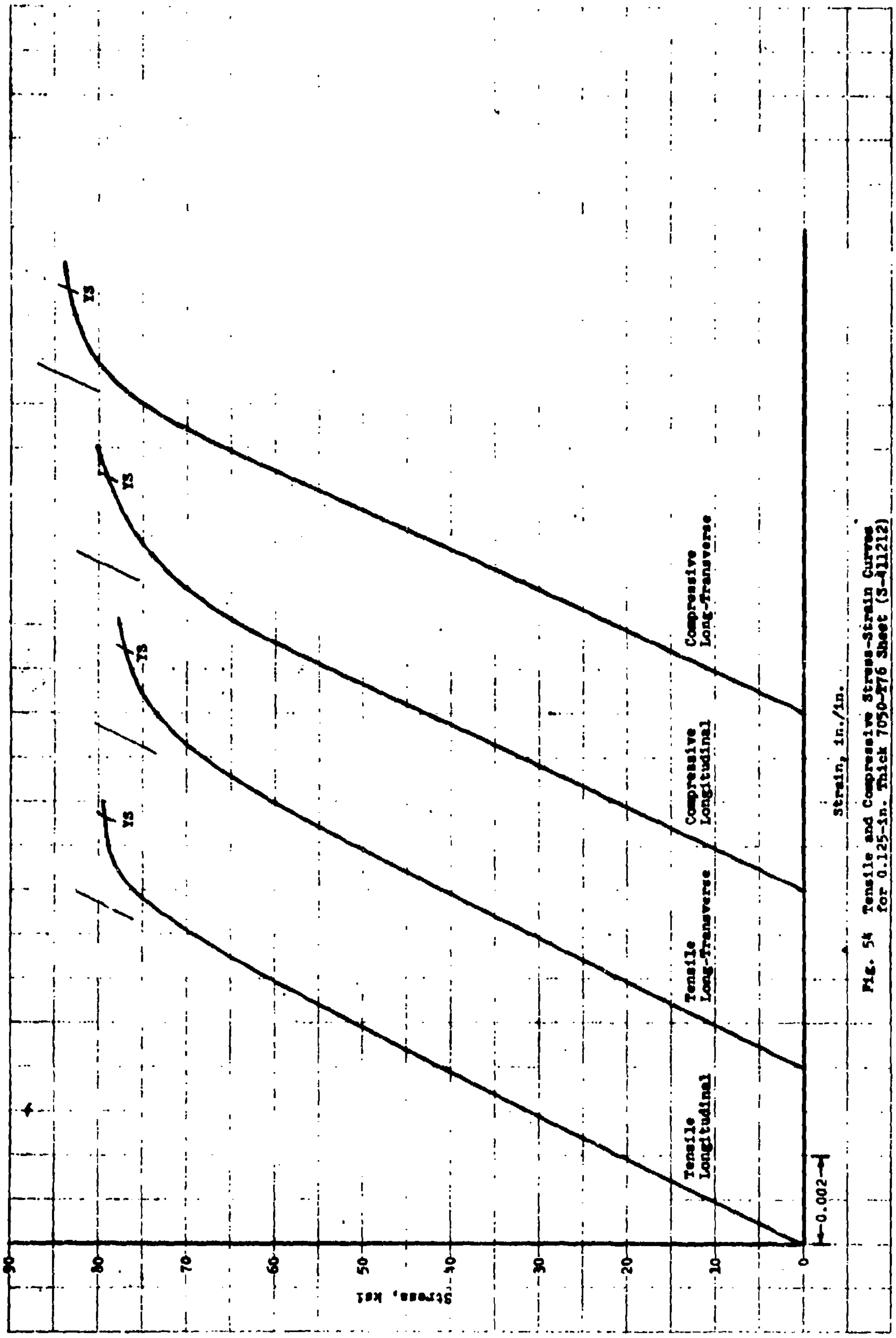


Fig. 54 Tensile and Compressive Stress-Strain Curves for 0.125-in. Thick 7050-T76 Sheet (3-411212)

Fig. 54

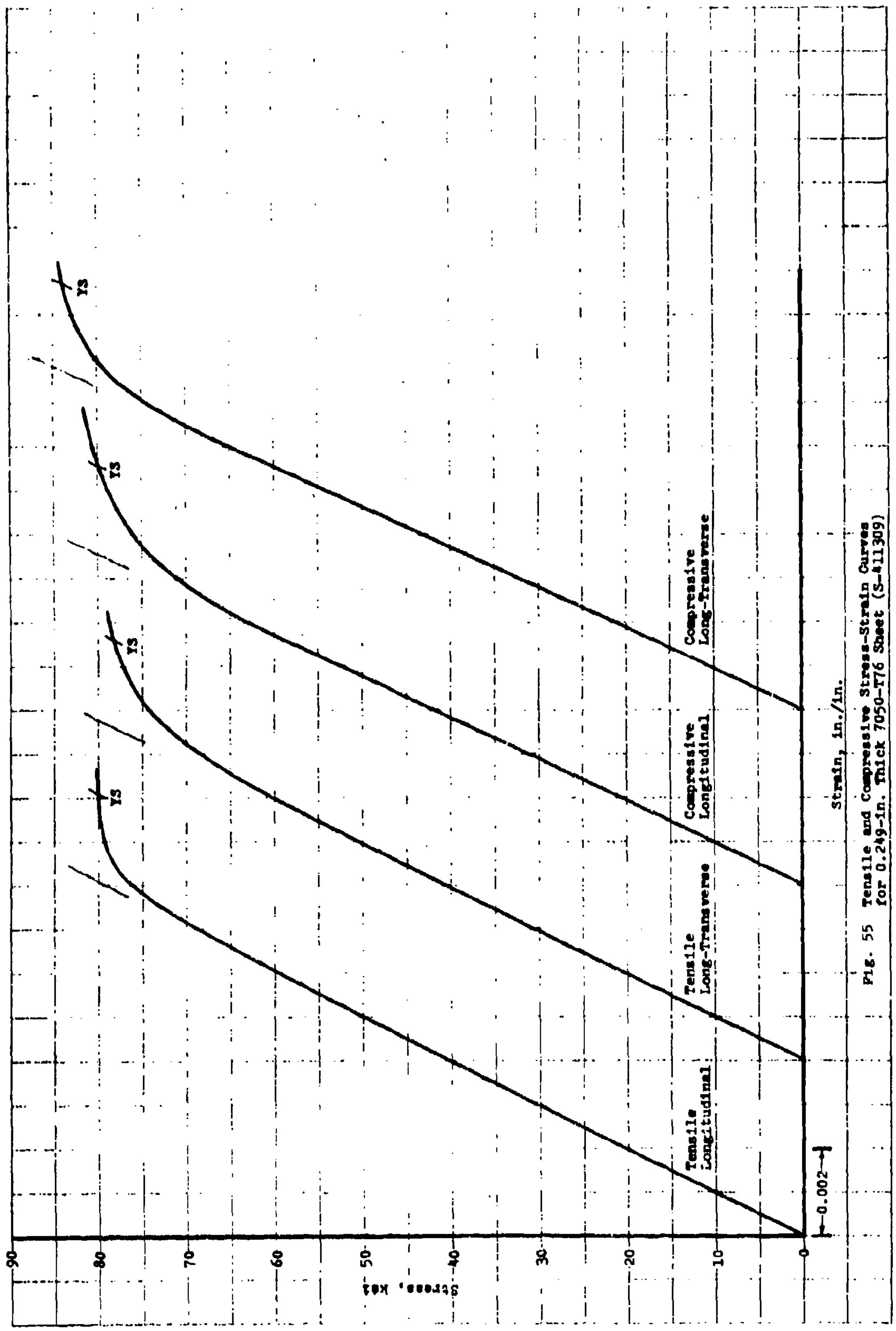


Fig. 55 Tensile and Compressive Stress-Strain Curves for 0.249-in. Thick 7050-T76 Sheet (S-411309)

Fig. 55

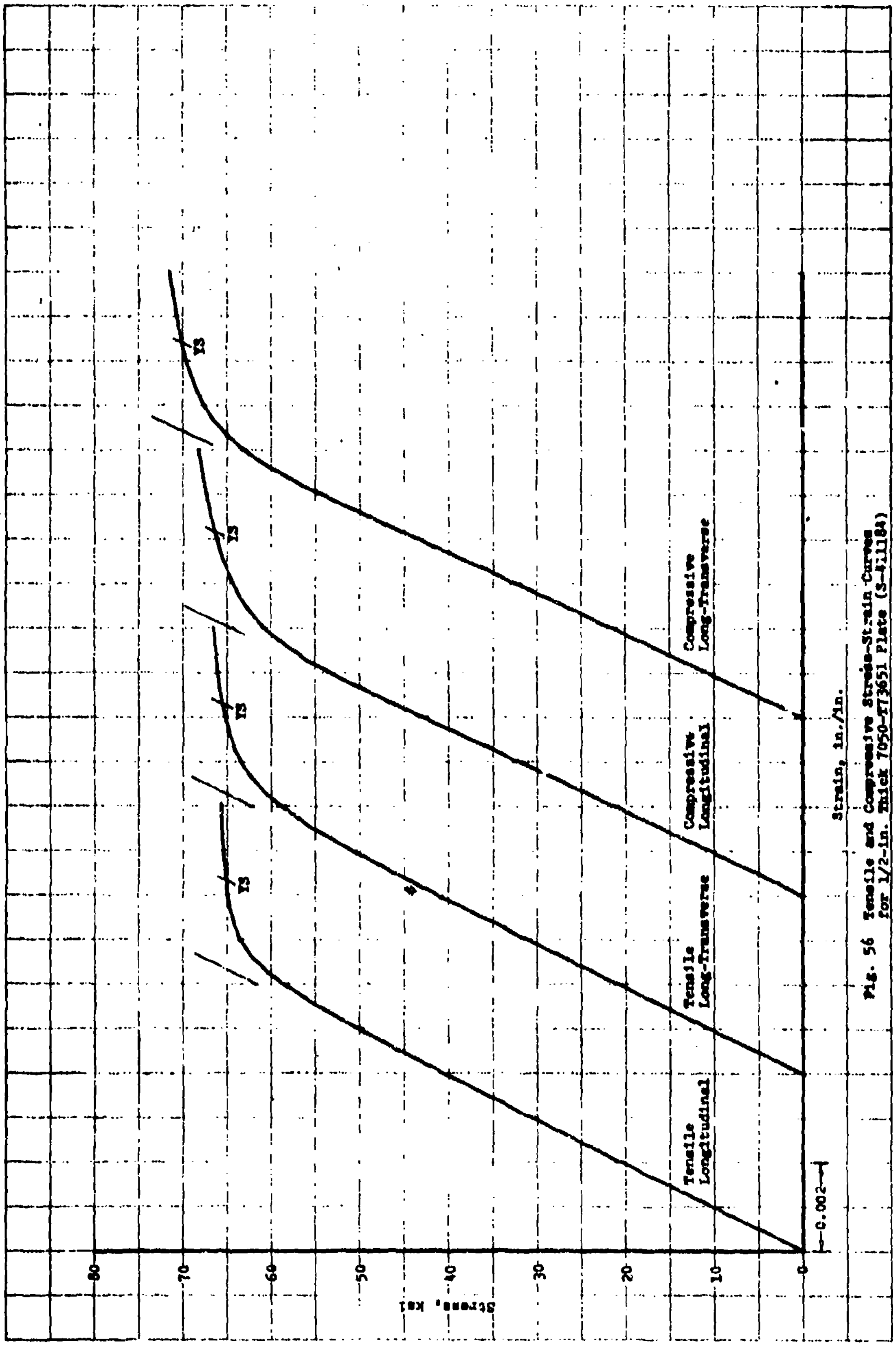


Fig. 56 Tensile and Compressive Stress-Strain Curves for 1/2-in. Thick 7050-T73651 Plate (S-411184)

Fig. 56

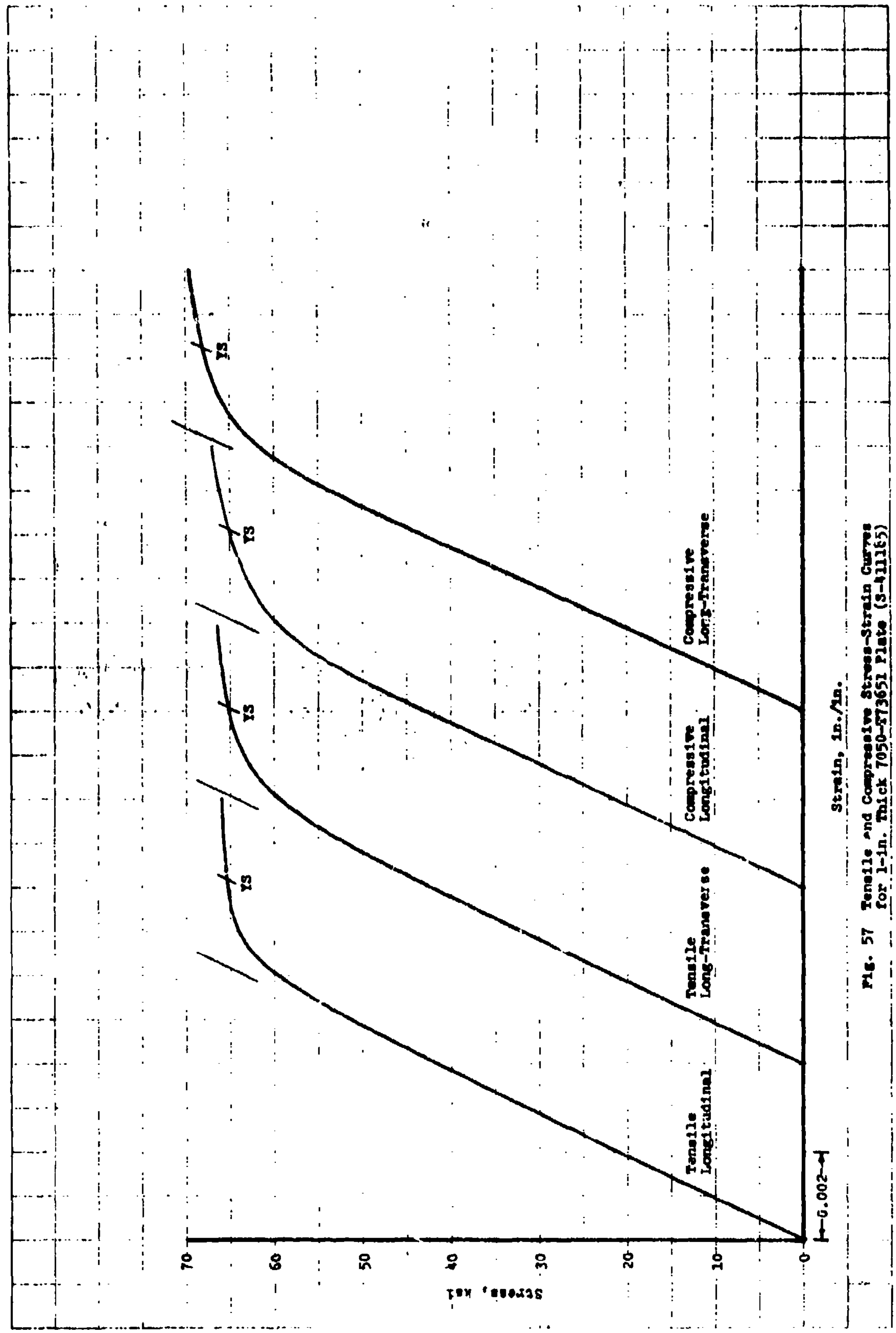


Fig. 57 Tensile and Compressive Stress-Strain Curves for 1-in. Thick 7050-T73651 Plate (S-41115)

Fig. 57

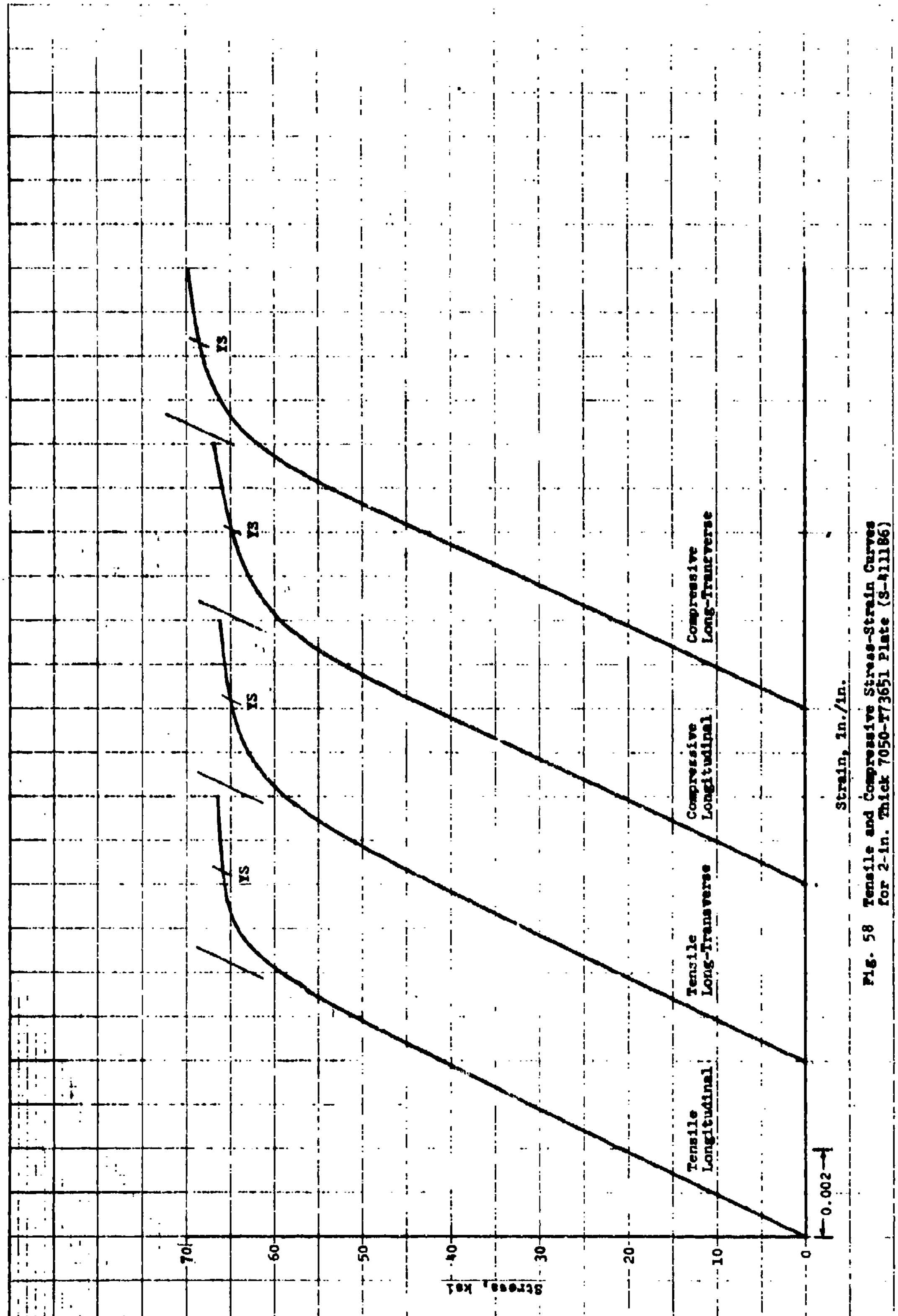


Fig. 58 Tensile and Compressive Stress-Strain Curves for 2-in. Thick 7050-T73651 Plate (S-411186)

Fig. 58

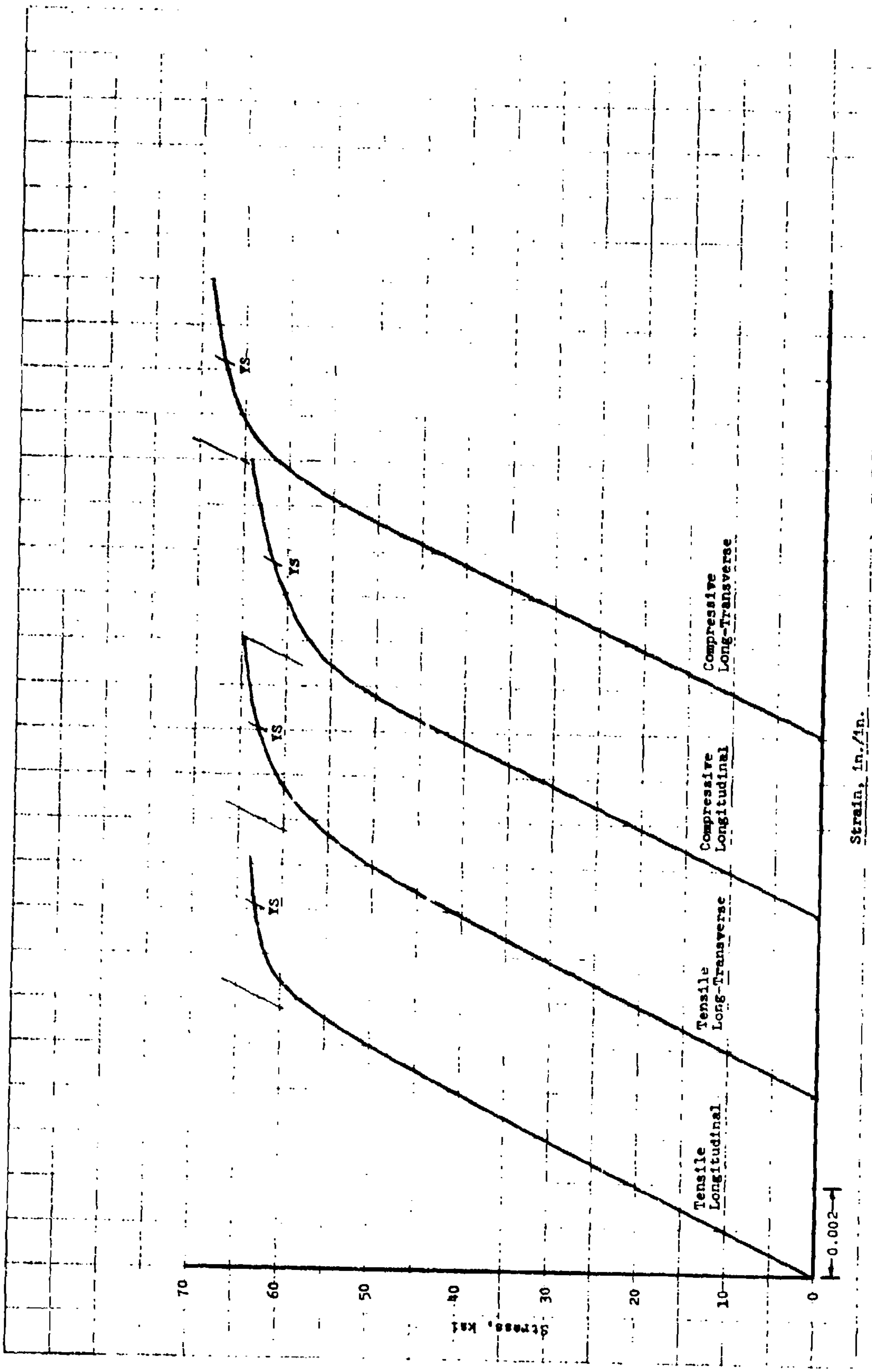


Fig. 59 Tensile and Compressive Stress-Strain Curves for 4-in. Thick 7050-T73651 Plate (S-411187)

Fig. 59

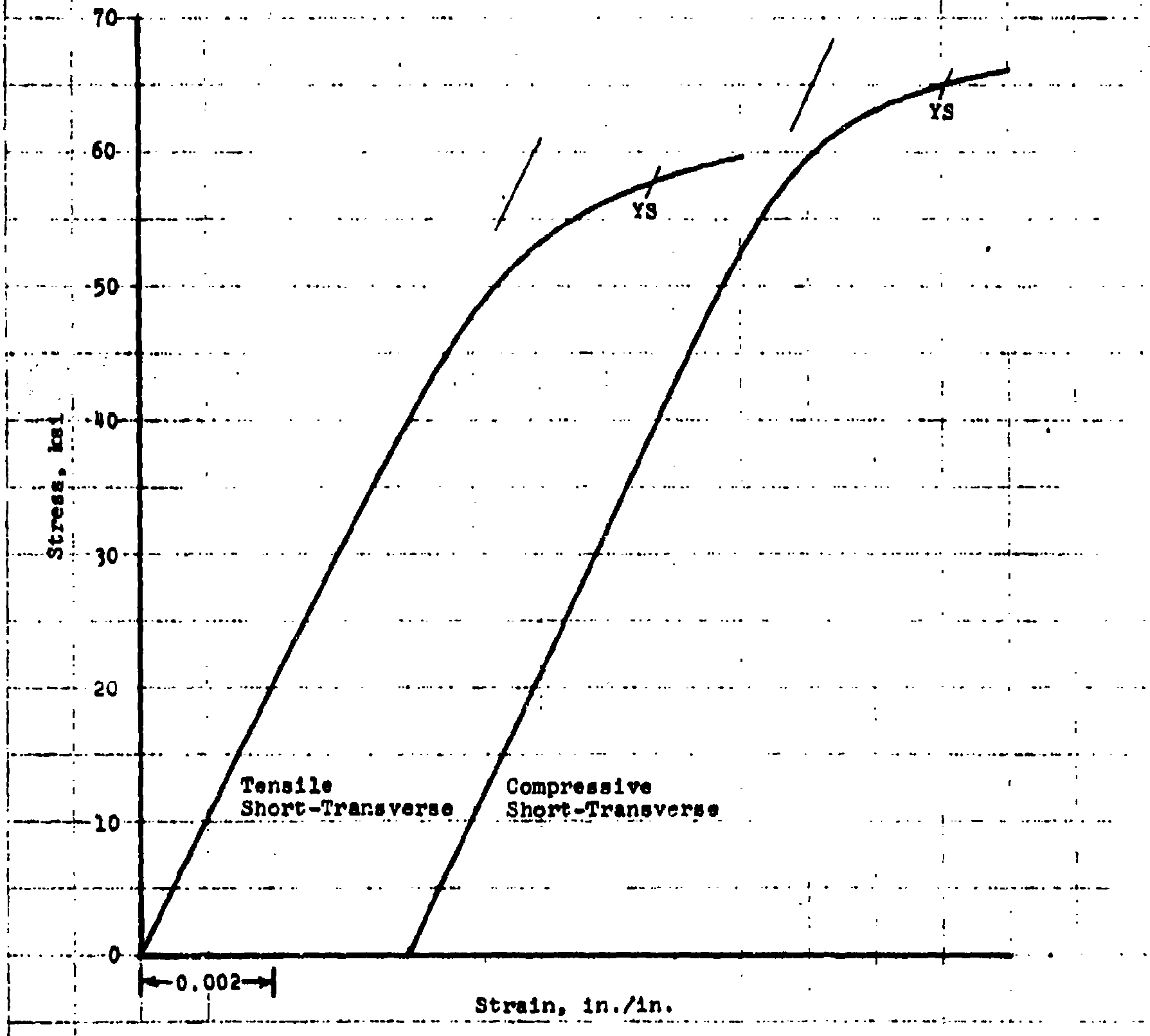


Fig. 60 Tensile and Compressive Stress-Strain Curves for 4-in. Thick 7050-T73651 Plate (S-411187)

Fig. 60

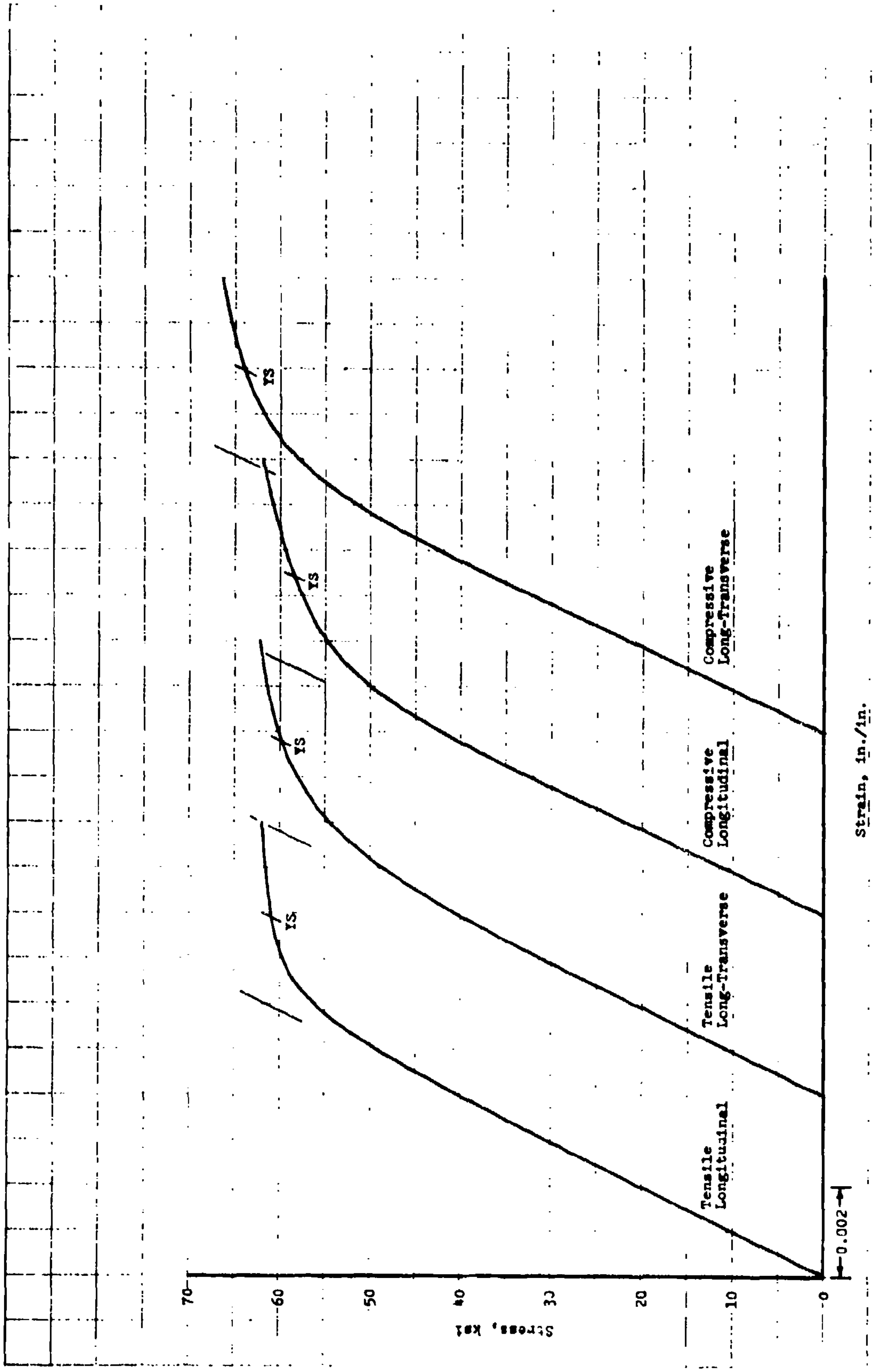


Fig. 61 Tensile and Compressive Stress-Strain Curves for 6-in. Thick 7050-T73651 Plate (S-41300)

Fig. 61

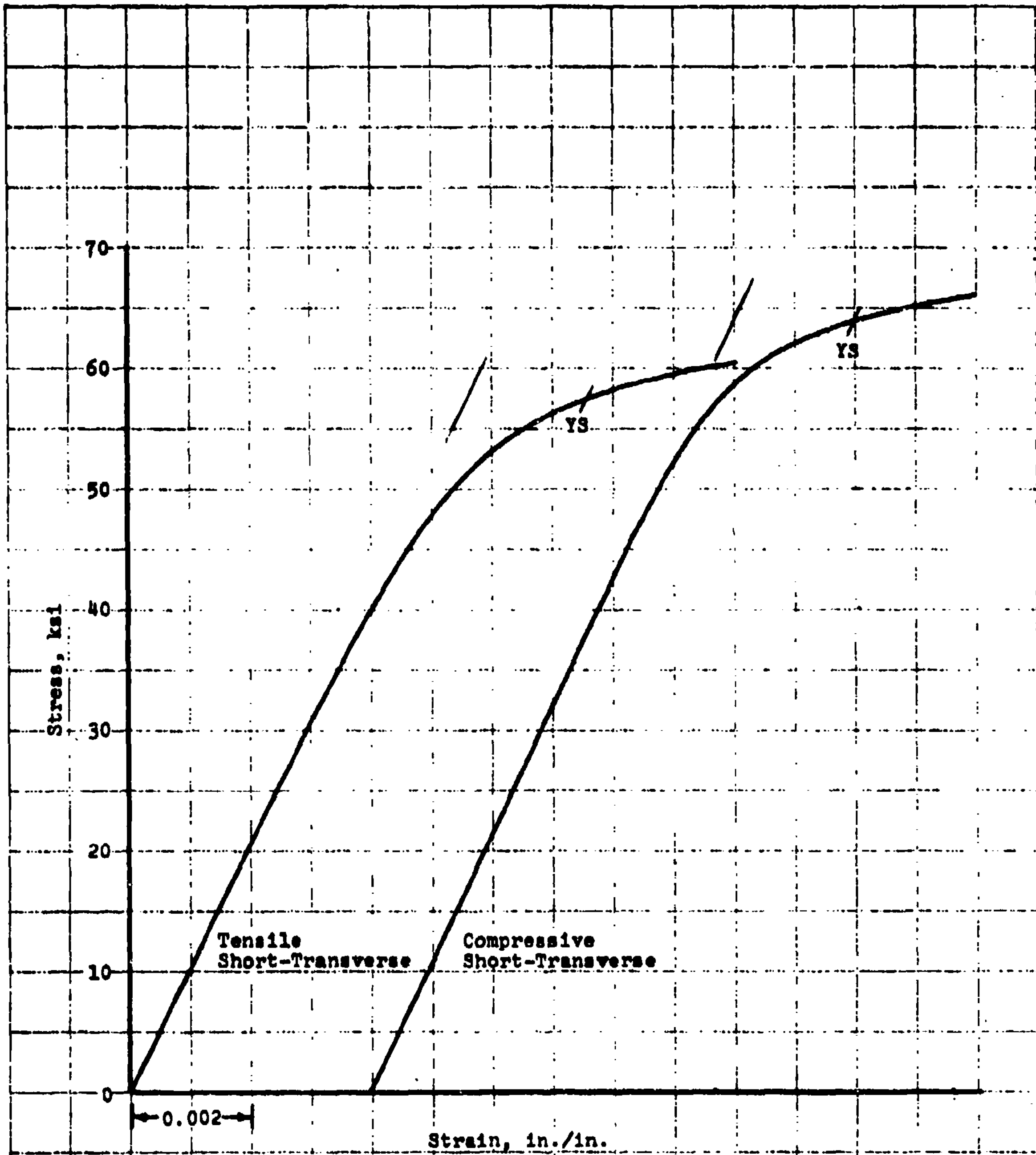


Fig. 62 Tensile and Compressive Stress-Strain Curves for 6-in. Thick 7050-T73651 Plate (S-411300)

Fig. 62

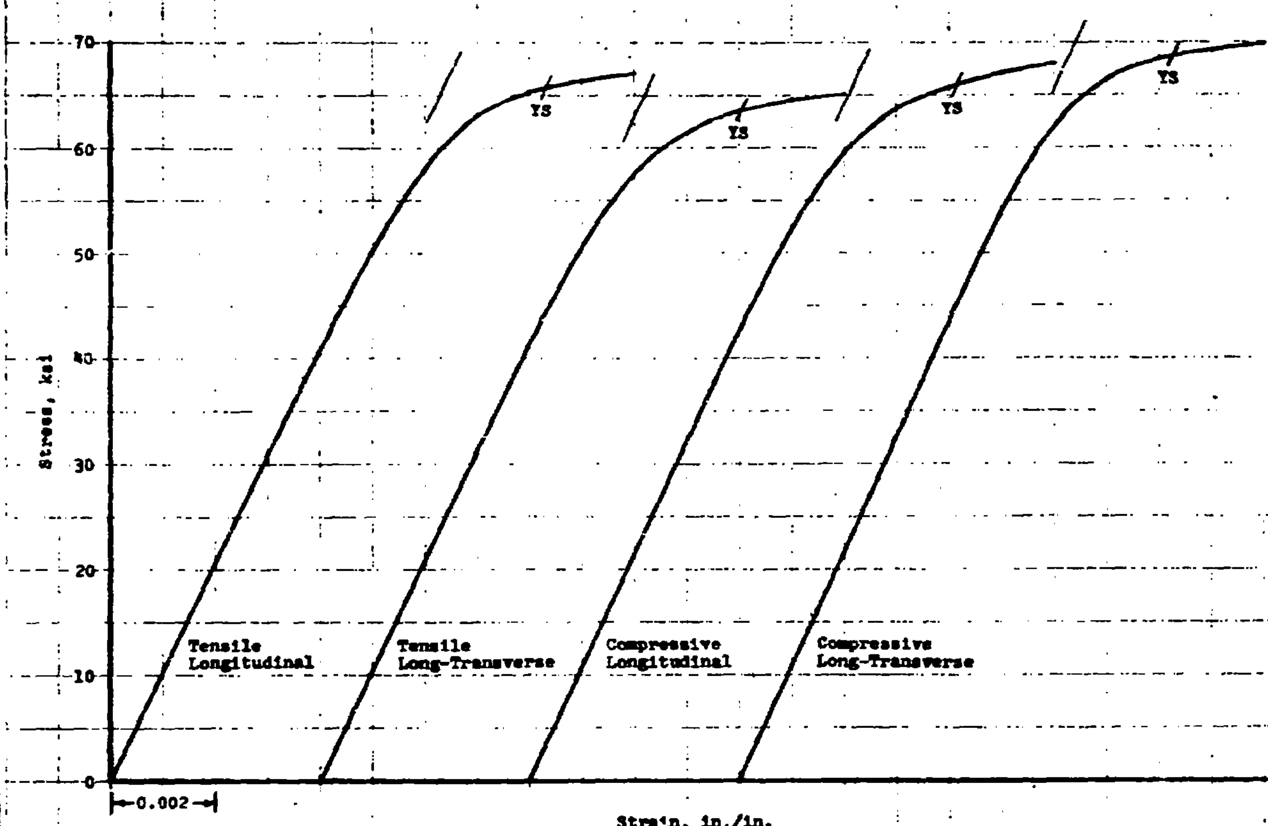


Fig. 63 Tensile and Compressive Stress-Strain Curves for 2-1/2-in. Thick 7050-T73652 Hand Forging (S-411229)

Fig. 63

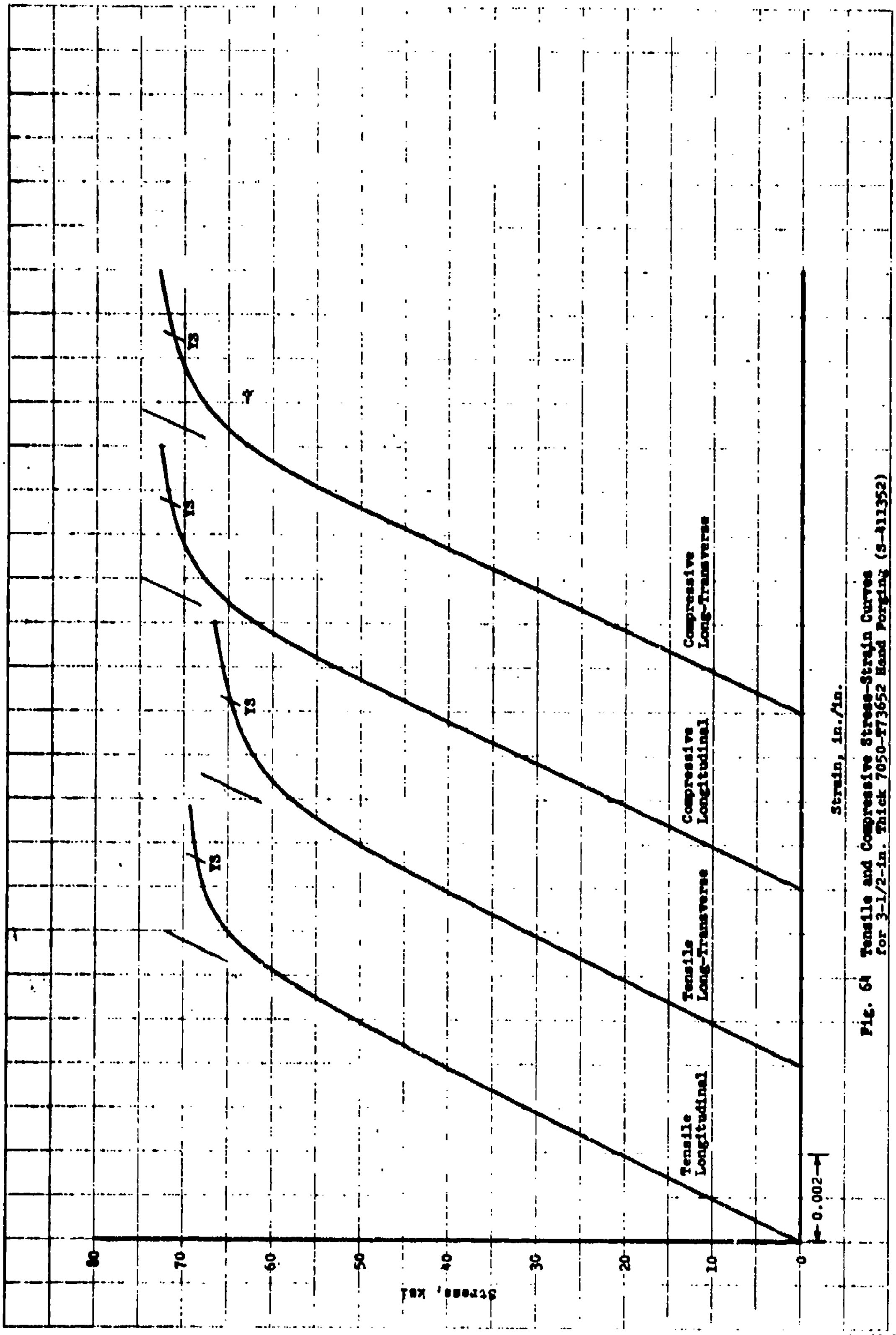


Fig. 64 Tensile and Compressive Stress-Strain Curves for 3-1/2-in. Thick 7050-T73652 Hand Forging (S-311352)

Fig. 64

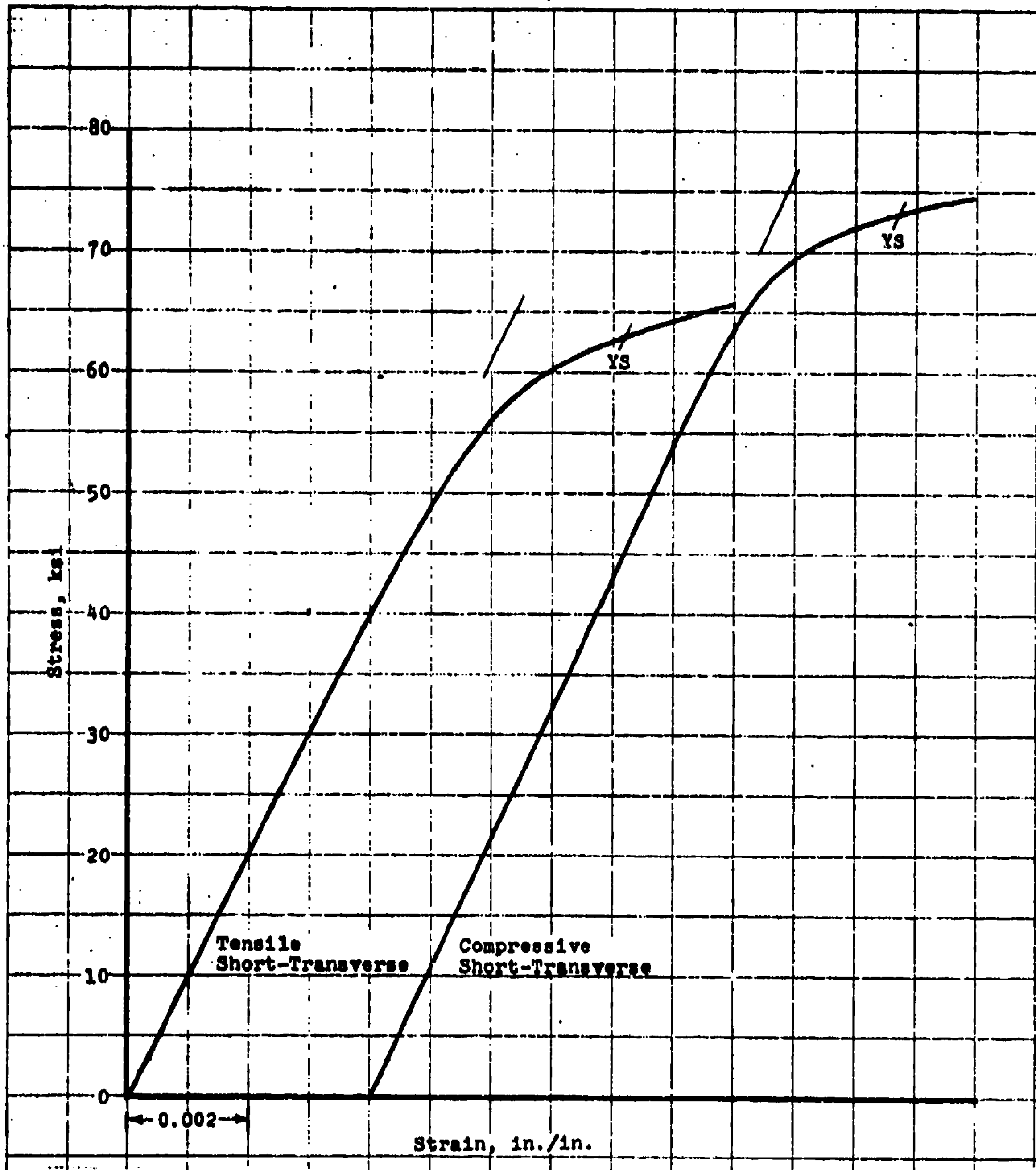


Fig. 65 Tensile and Compressive Stress-Strain Curves for 3-1/2-in. Thick 7050-T73652 Hand Forging (S-411352)

Fig. 65

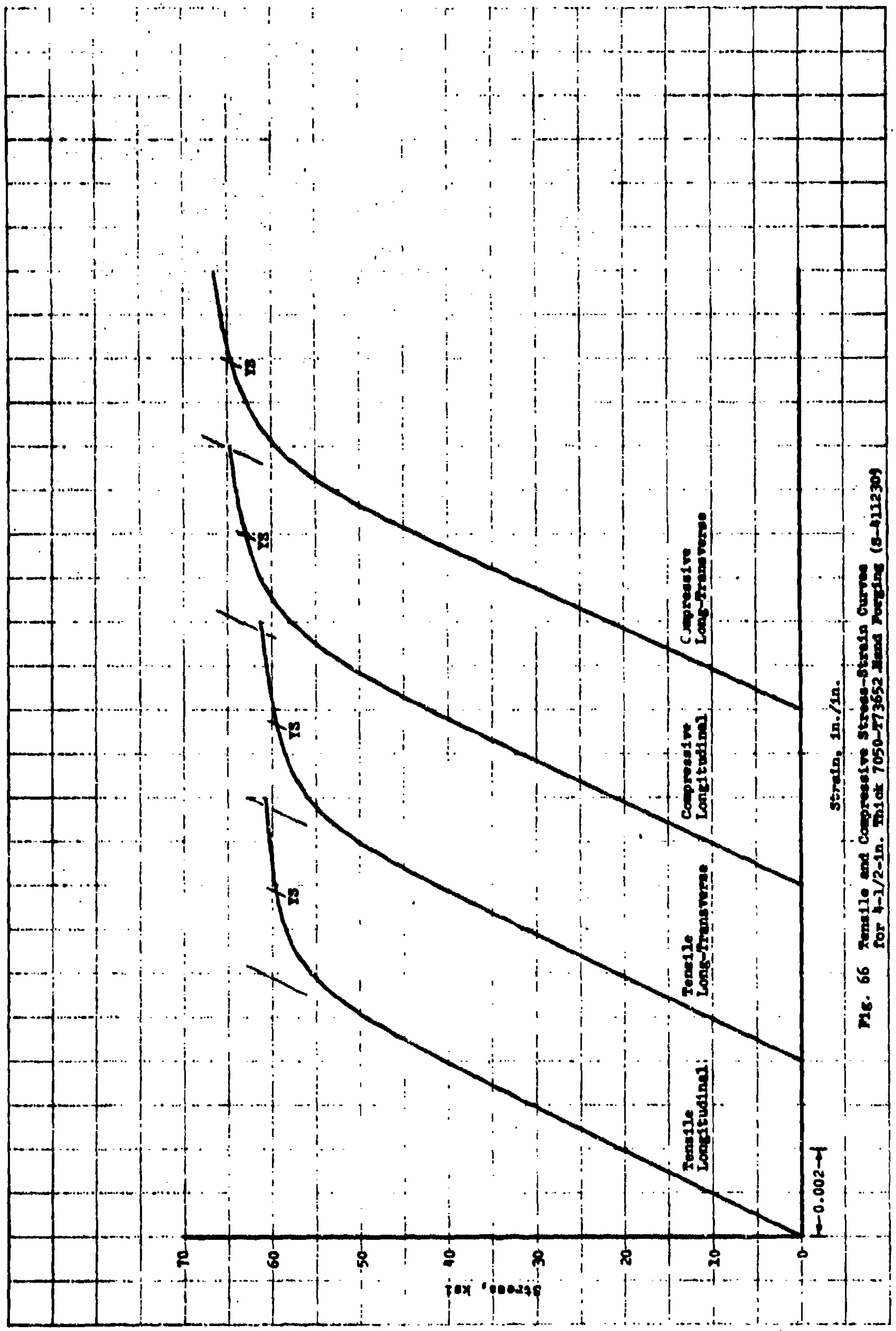


Fig. 66 Tensile and Compressive Stress-Strain Curves for 4-1/2-in. Thick 7050-T73652 Hand Forging (S-411230)

Fig. 66

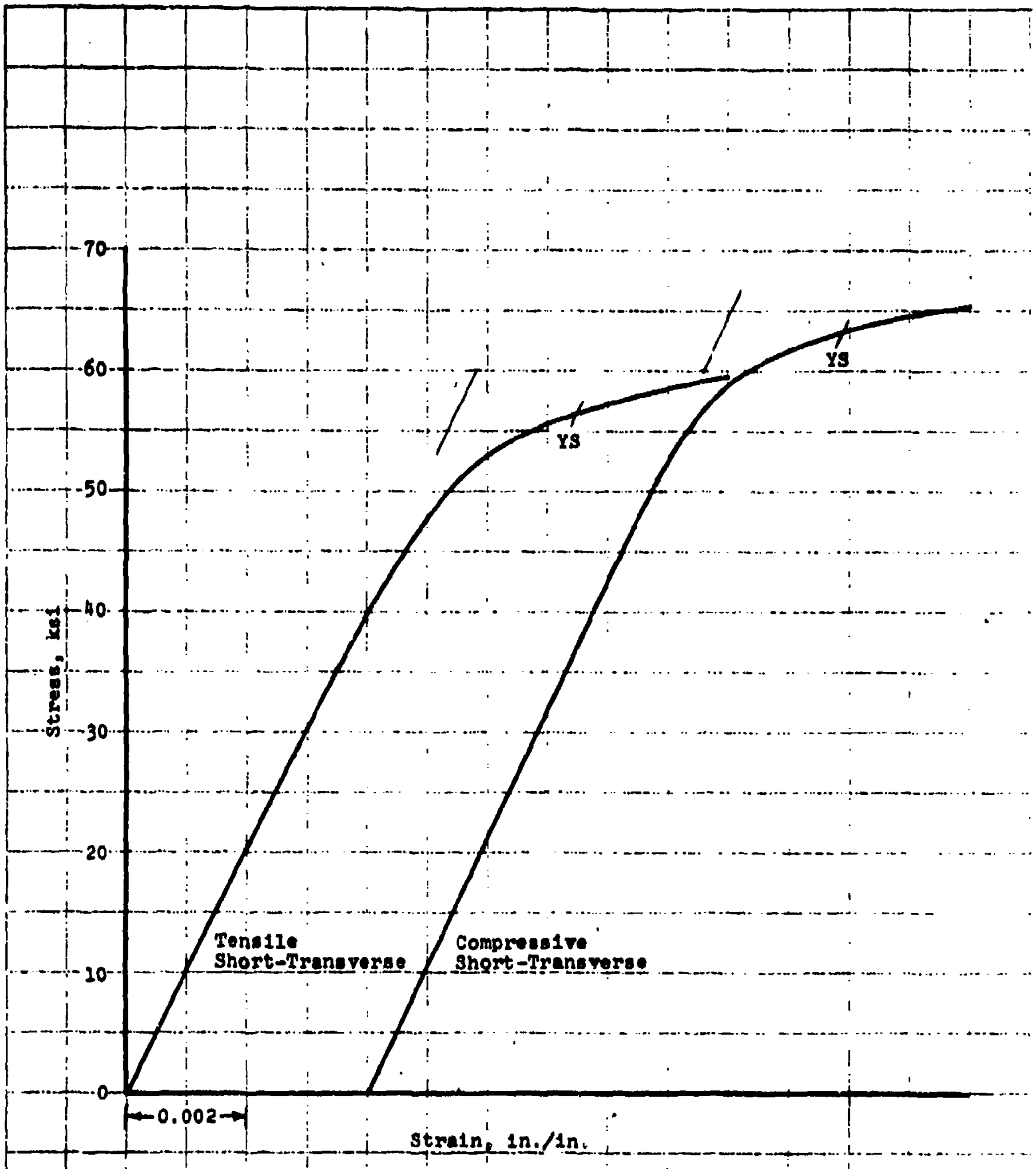


Fig. 67 Tensile and Compressive Stress-Strain Curves for 4-1/2-in. Thick 7050-T73652 Hand Forging (S-411230)

Fig. 67

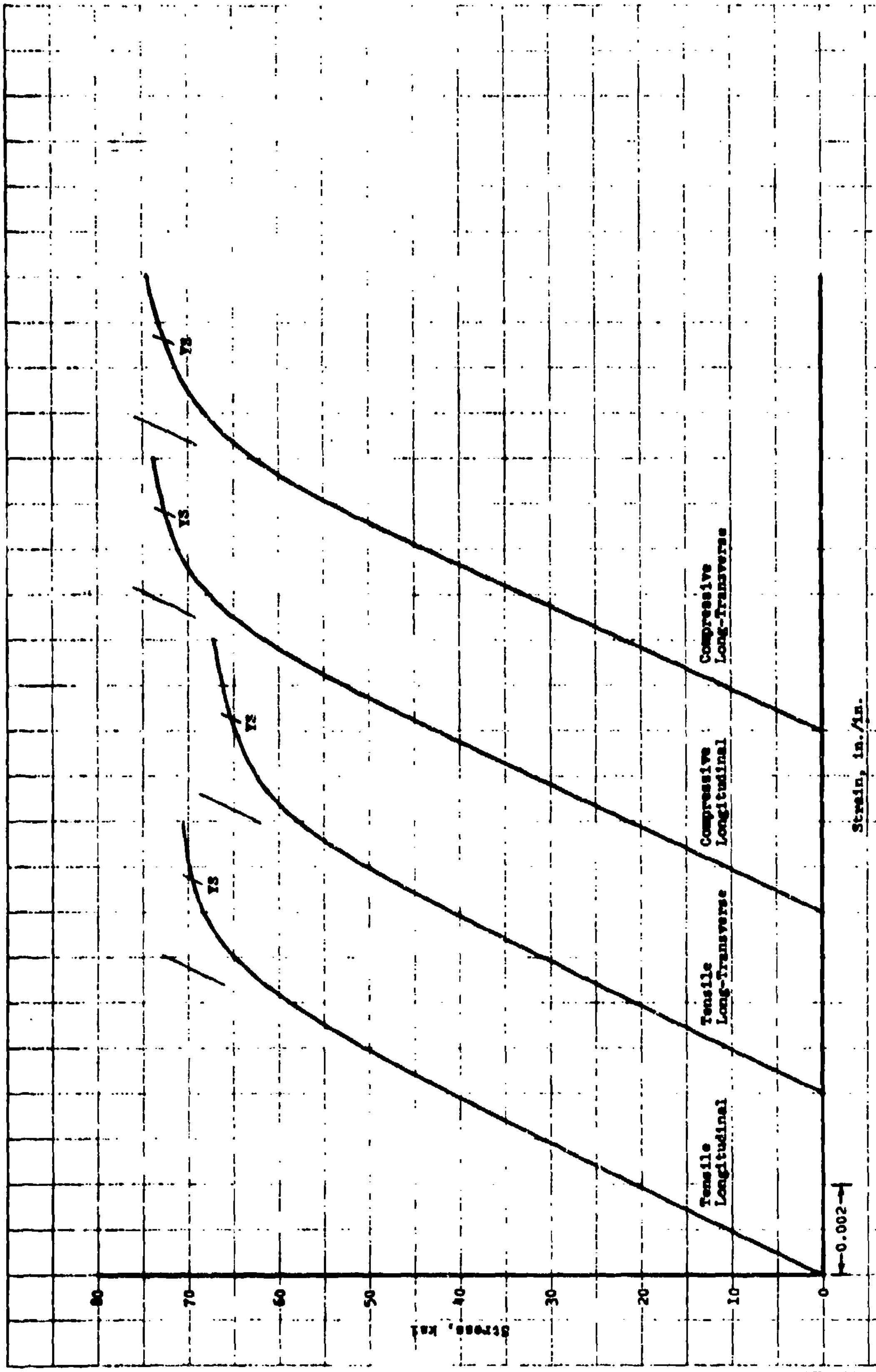


Fig. 68 Tensile and Compressive Stress-Strain Curves for 5-1/2-in. Thick 7050-T73652 Hand Forging (S-411353)

Fig. 68

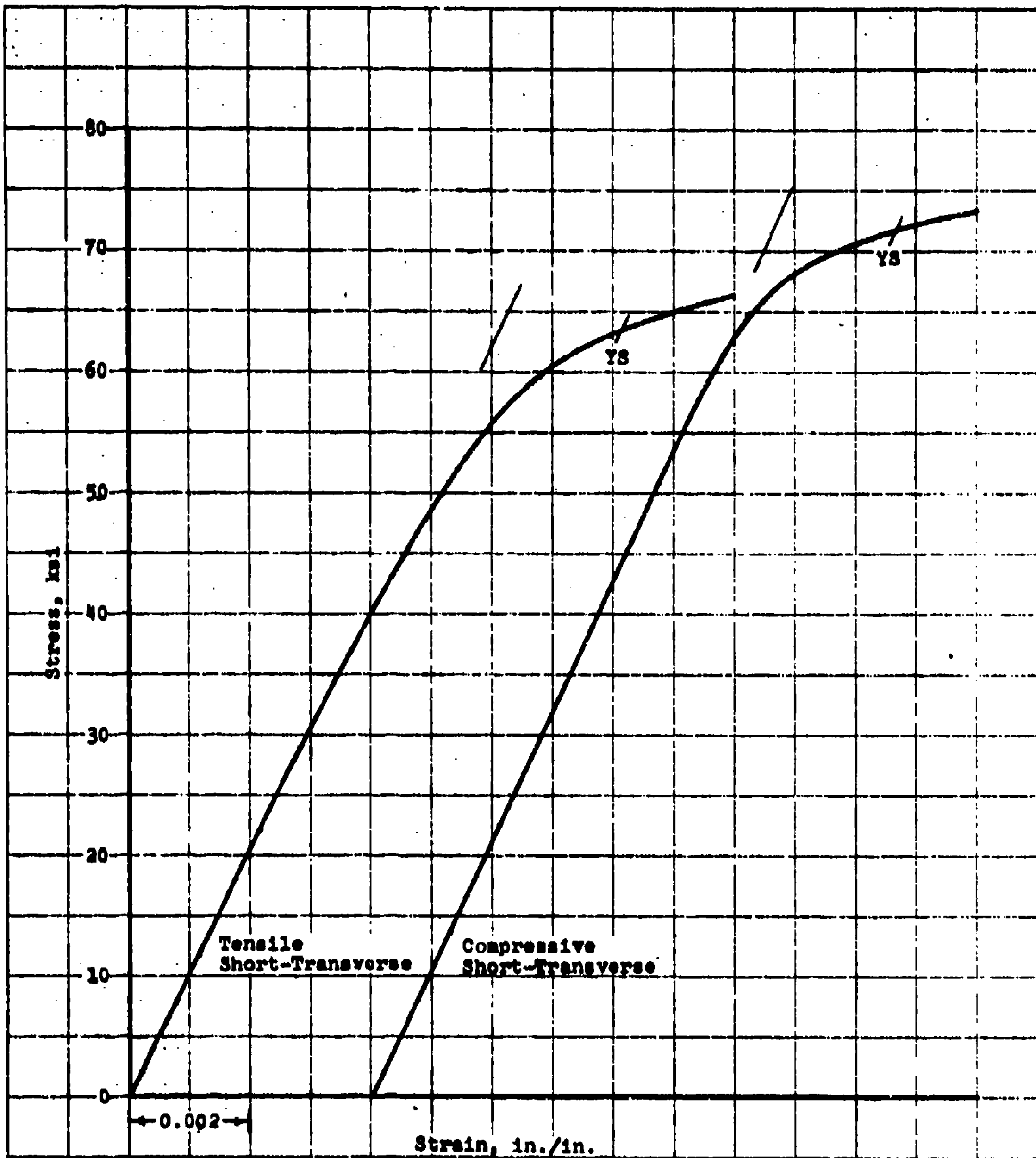


Fig. 69 Tensile and Compressive Stress-Strain Curves for 5-1/2-in. Thick 7050-T73652 Hand Forging (S-411353)

Fig. 69

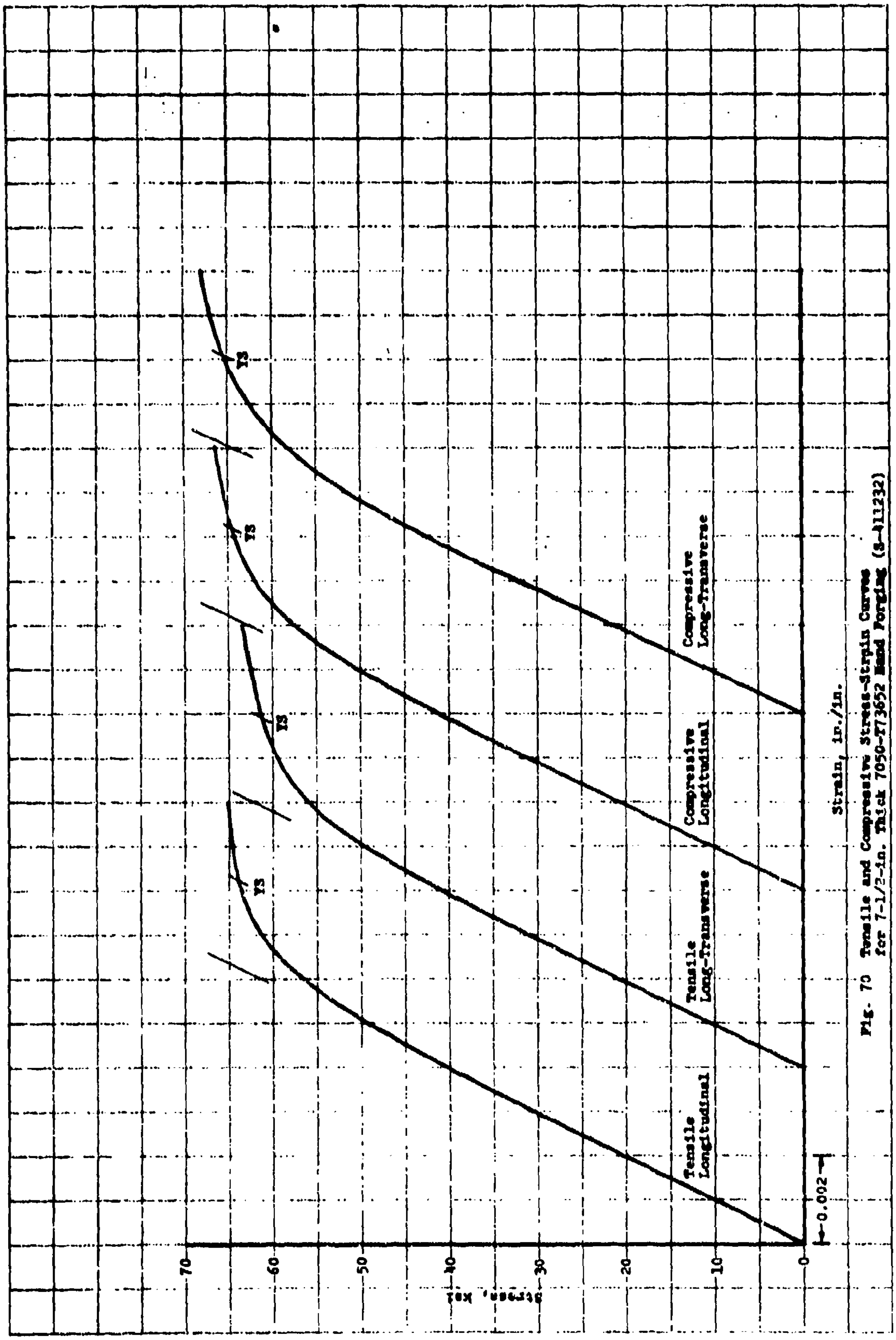


Fig. 70 Tensile and Compressive Stress-Strain Curves for 7-1/2-in. Thick 7050-T73652 Hand Forging (S-411232)

Fig. 70

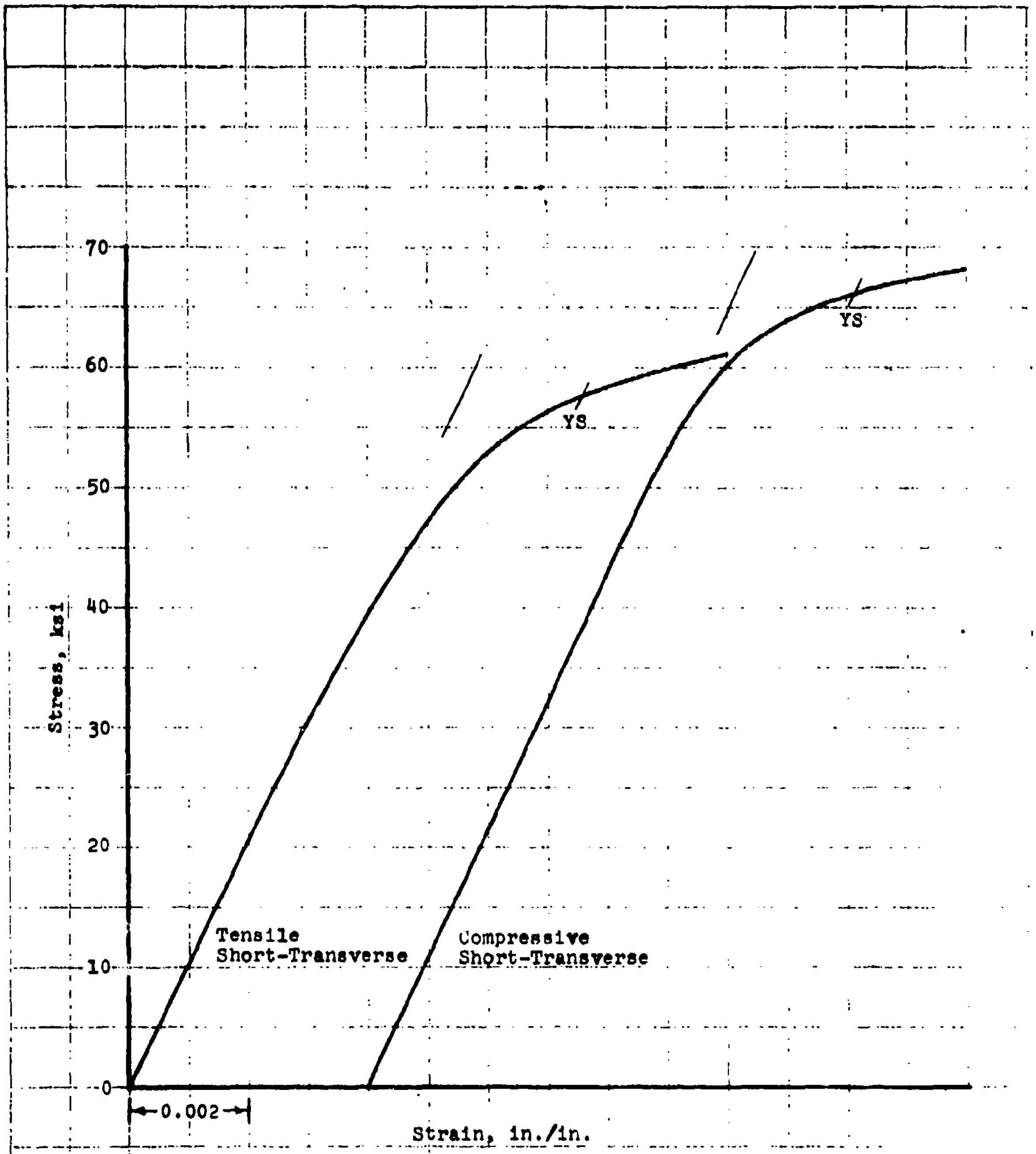


Fig. 71 Tensile and Compressive Stress-Strain Curves for 7-1/2-in. Thick 7050-T73652 Hand Forging (S-411232)

Fig. 71

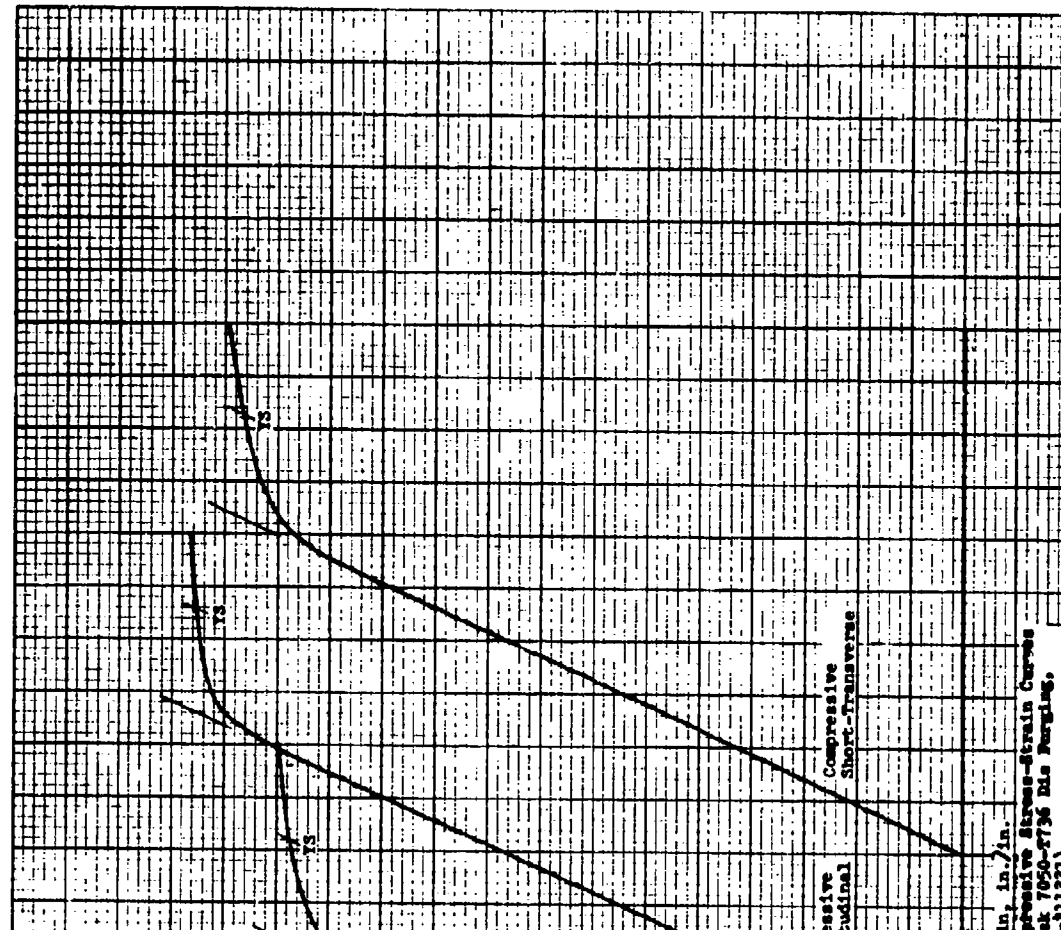


Fig. 72 Tensile and Compressive Stress-Strain Curves for 0.7-in. Thick 7050-F736 Die Forging, Die No. 9078 (S-411331)

Fig. 72

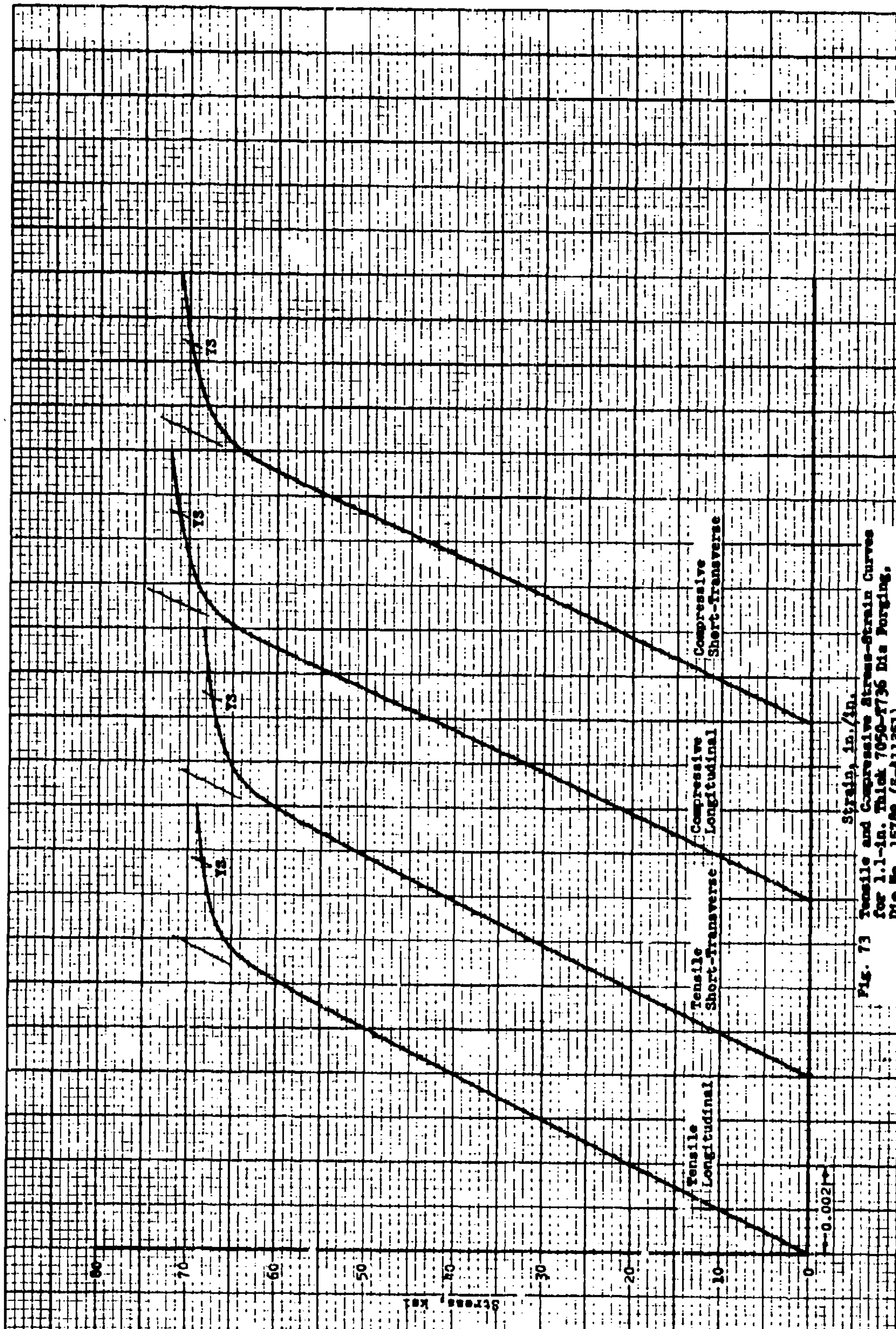


Fig. 73 Tensile and Compressive Stress-Strain Curves for 1.1-in. Thick 7050-T736 Die Forging, Die No. 15789 (S-411351)

Fig. 73

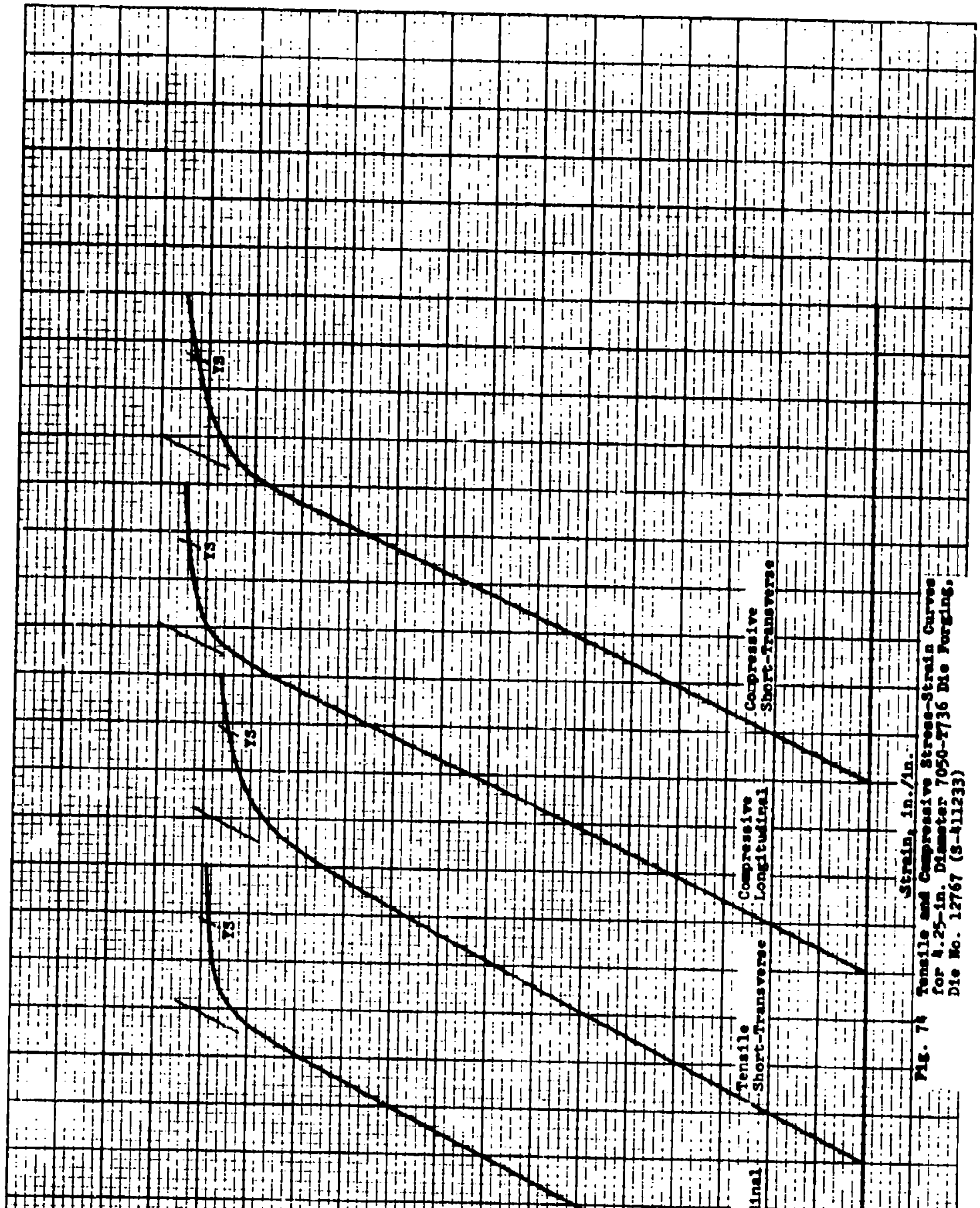


Fig. 74 Tensile and Compressive Stress-Strain Curves for 4.25-in. Diameter 7050-F7736 Die Forging, Die No. 12767 (S-411233)

Fig. 74

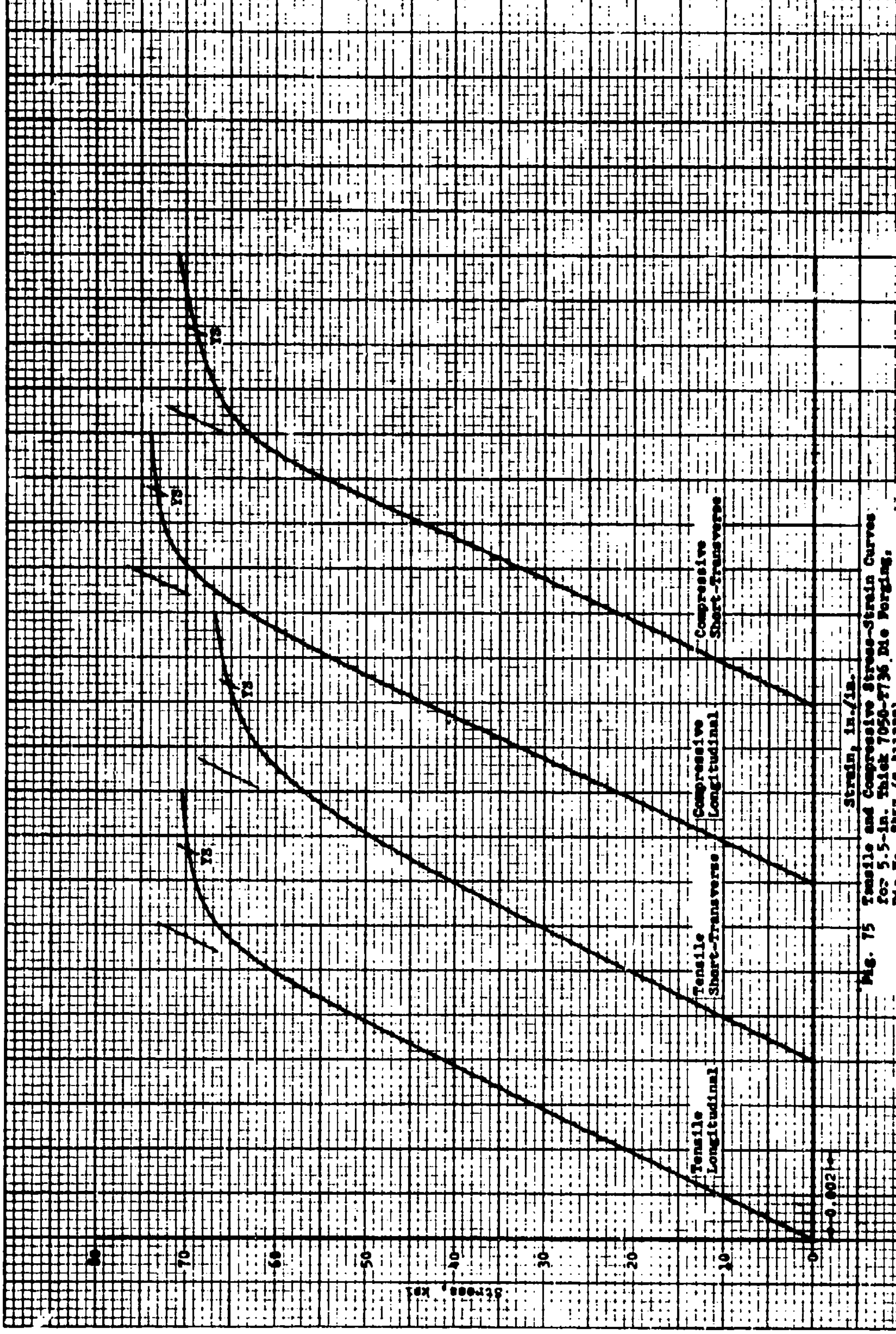


Fig. 75 Tensile and Compressive Stress-Strain Curves for 5.5-in. Thick 7050-F736 Die Forging; Die No. 8457 (S-411332)

Fig. 75

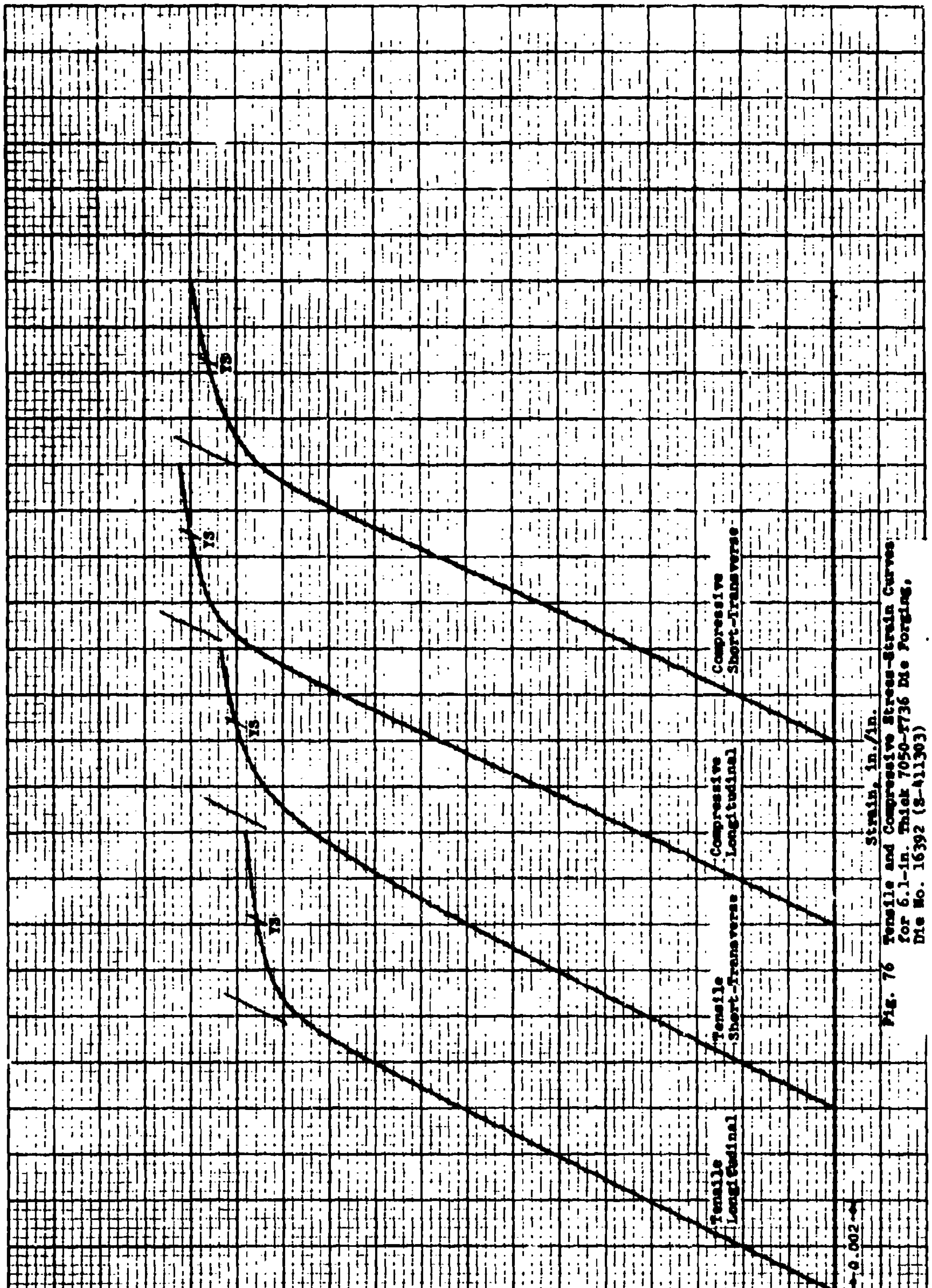


Fig. 76 Tensile and Compressive Stress-Strain Curves for 6.1-in. Thick 7050-T736 Die Forging, Die No. 16392 (S-411303)

Fig. 76

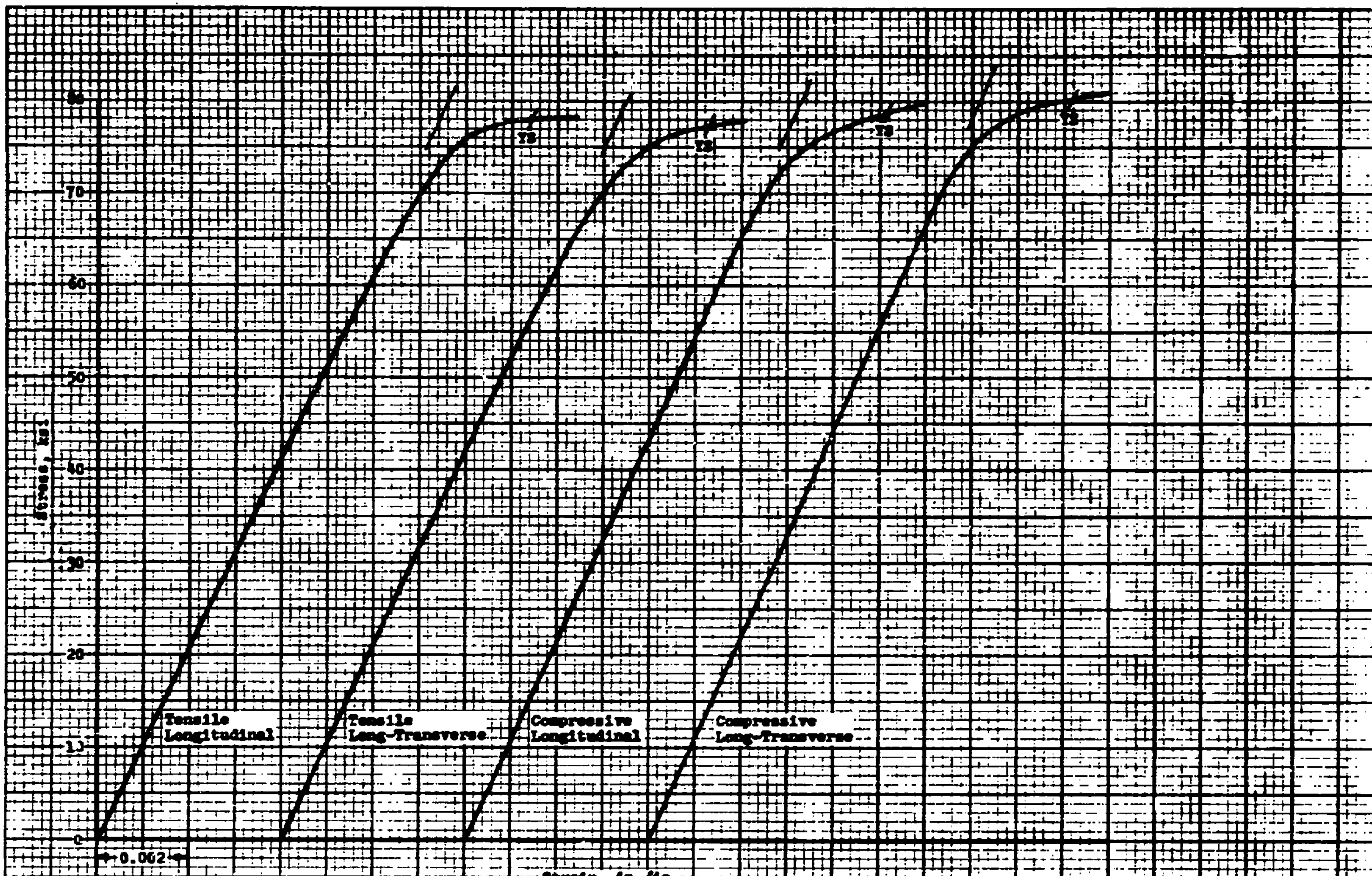


Fig. 77 Tensile and Compressive Stress-Strain Curves for 0.187-in. Thick 7050-T76511 Extruded Shape, Die No. 86366 (S-411288)

Fig. 77

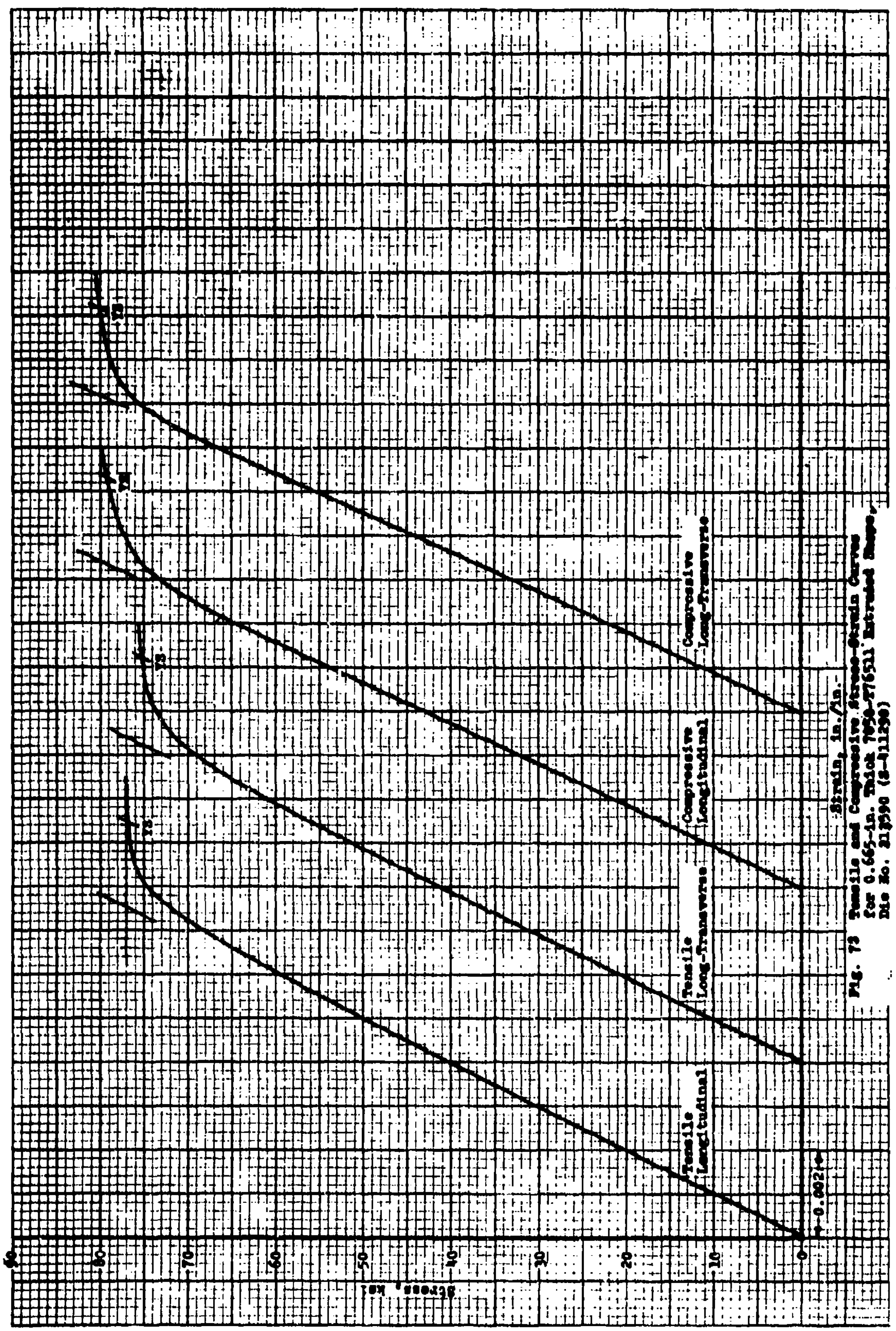


Fig. 78 Tensile and Compressive Stress-Strain Curves for 0.665-in. Thick 7050-T76511 Extruded Shape, Die No. 313590 (S-311290)

Fig. 78

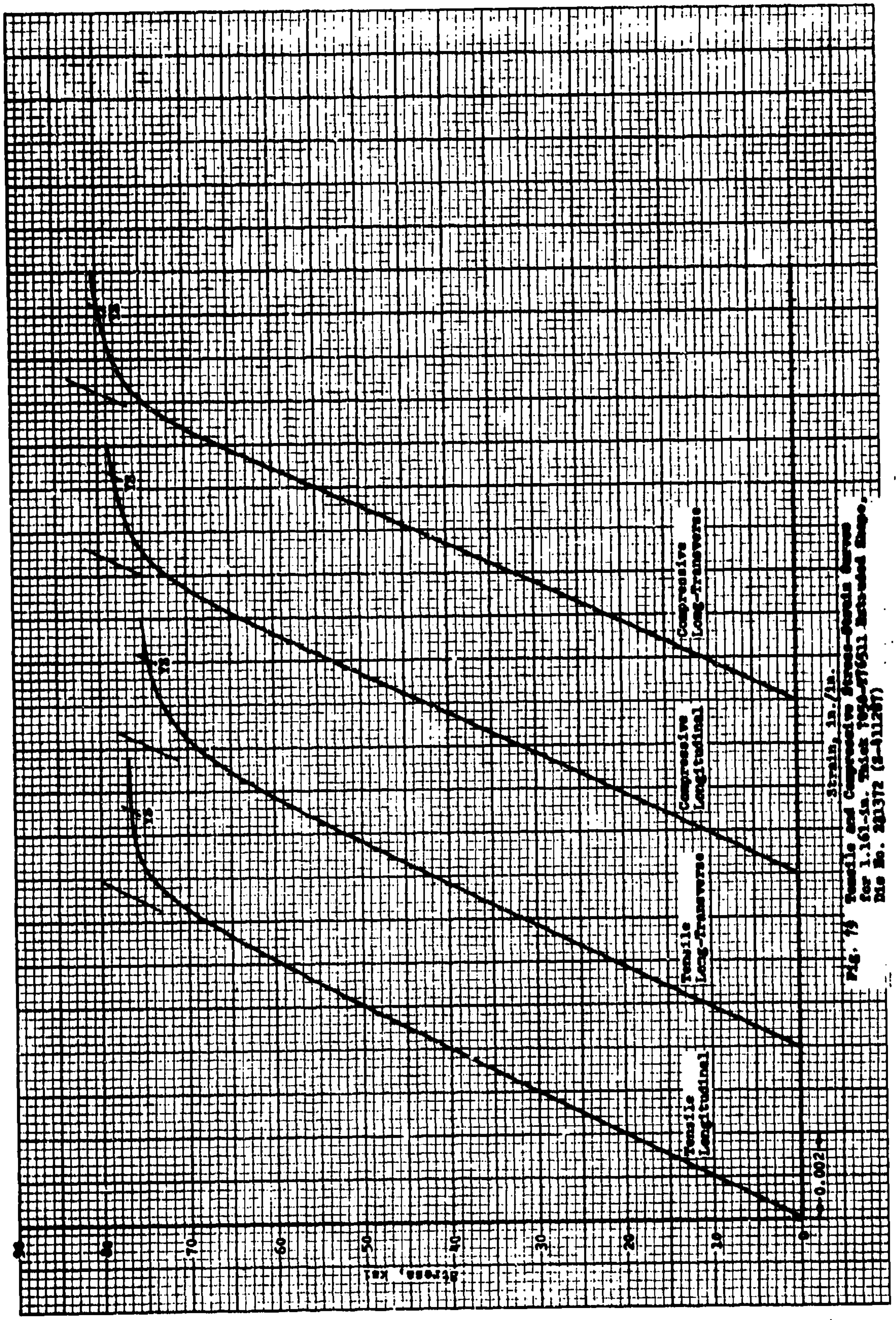


Fig. 79 Tensile and Compressive Stress-Strain Curves for 1.161-in. Thick 7075-T76511 Extruded Shape, Die No. 281372 (E-411207)

Fig. 79

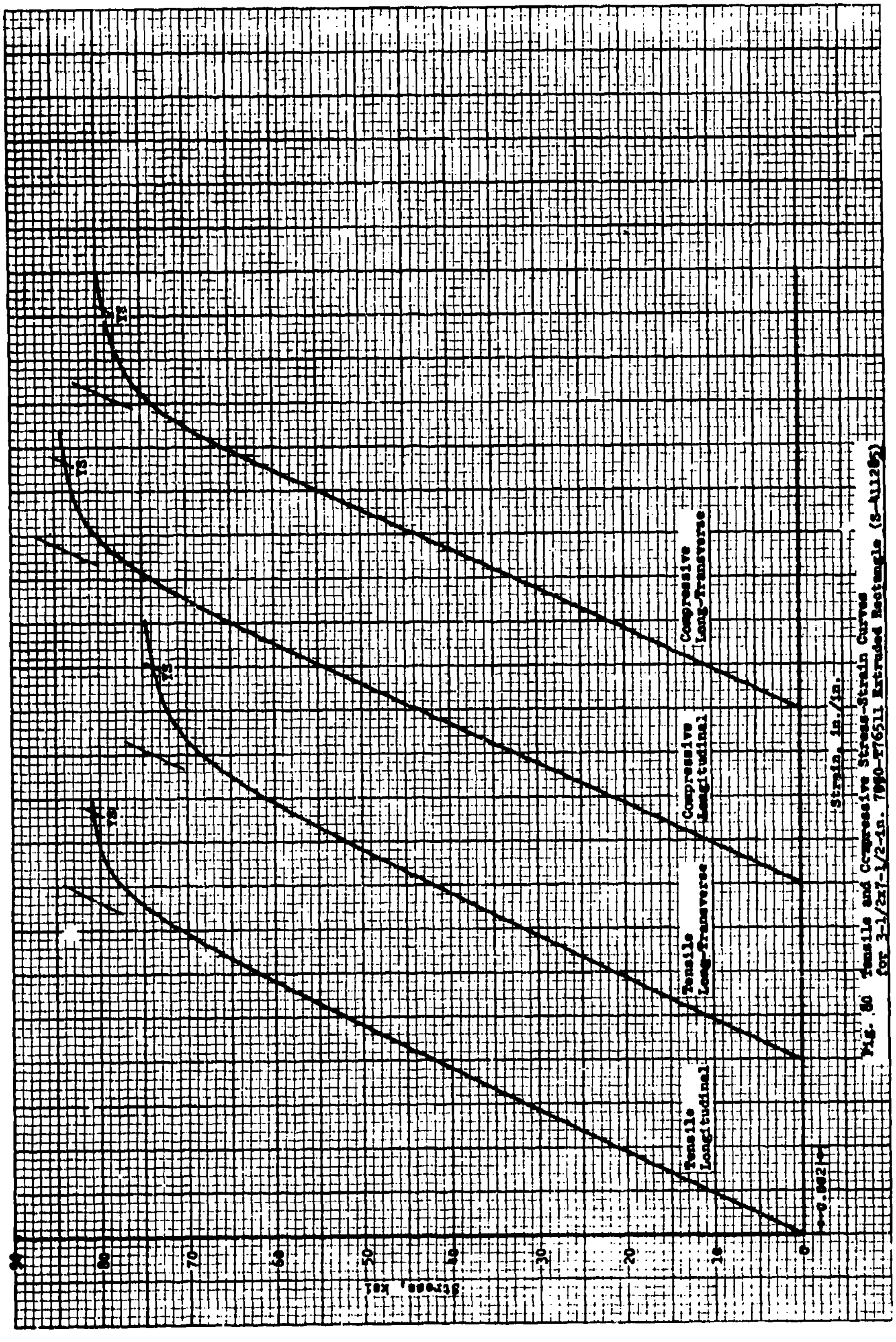


Fig. 80 Tensile and Compressive Stress-Strain Curves for 3-1/2x7-1/2-in. 7090-T76511 Extruded Rectangle (S-41128)

Fig. 80

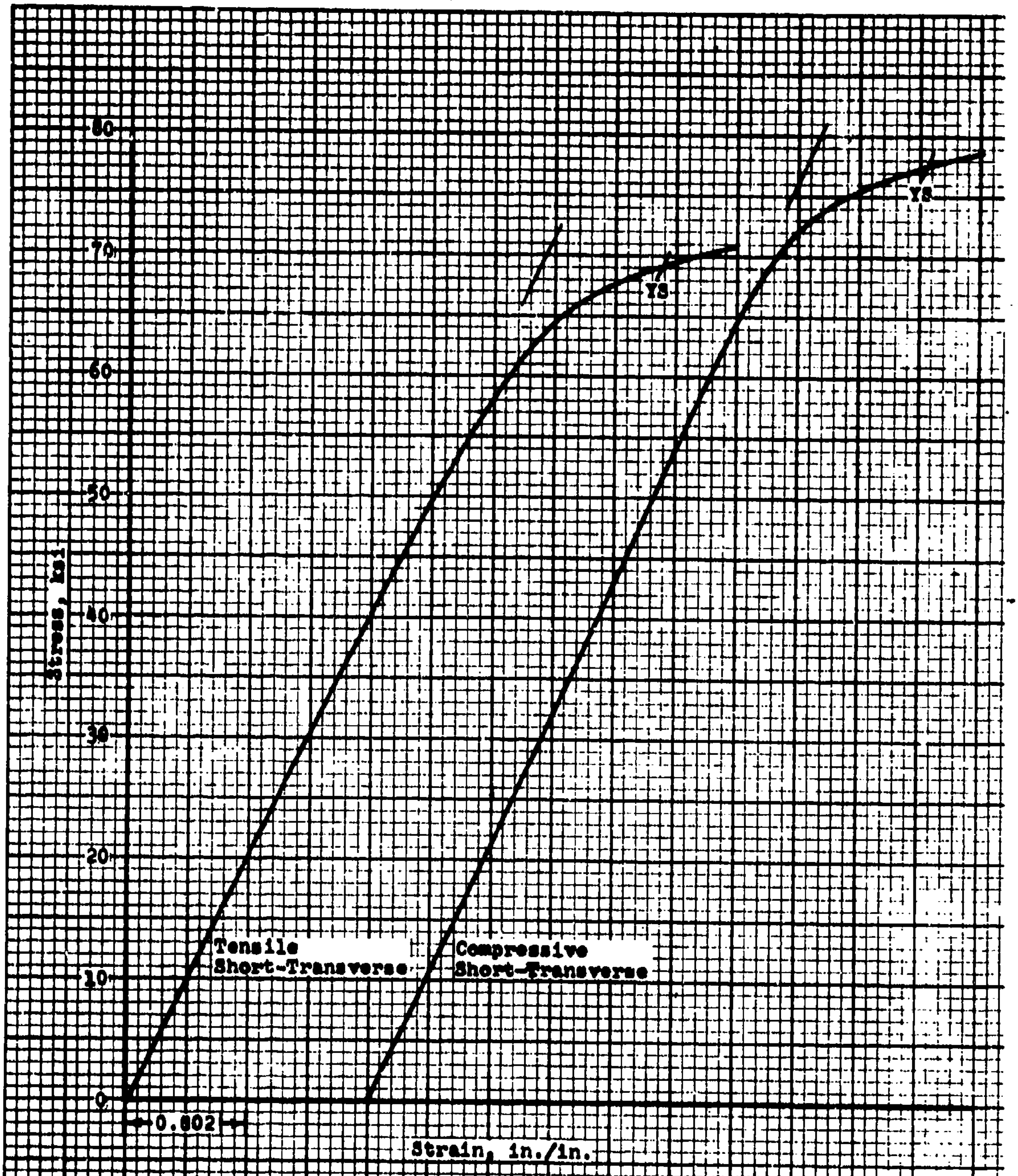


Fig. 81 Tensile and Compressive Stress-Strain Curves for 3-1/2x7-1/2-in. 7050-T76511 Extruded Rectangle (S-411285)

Fig. 81

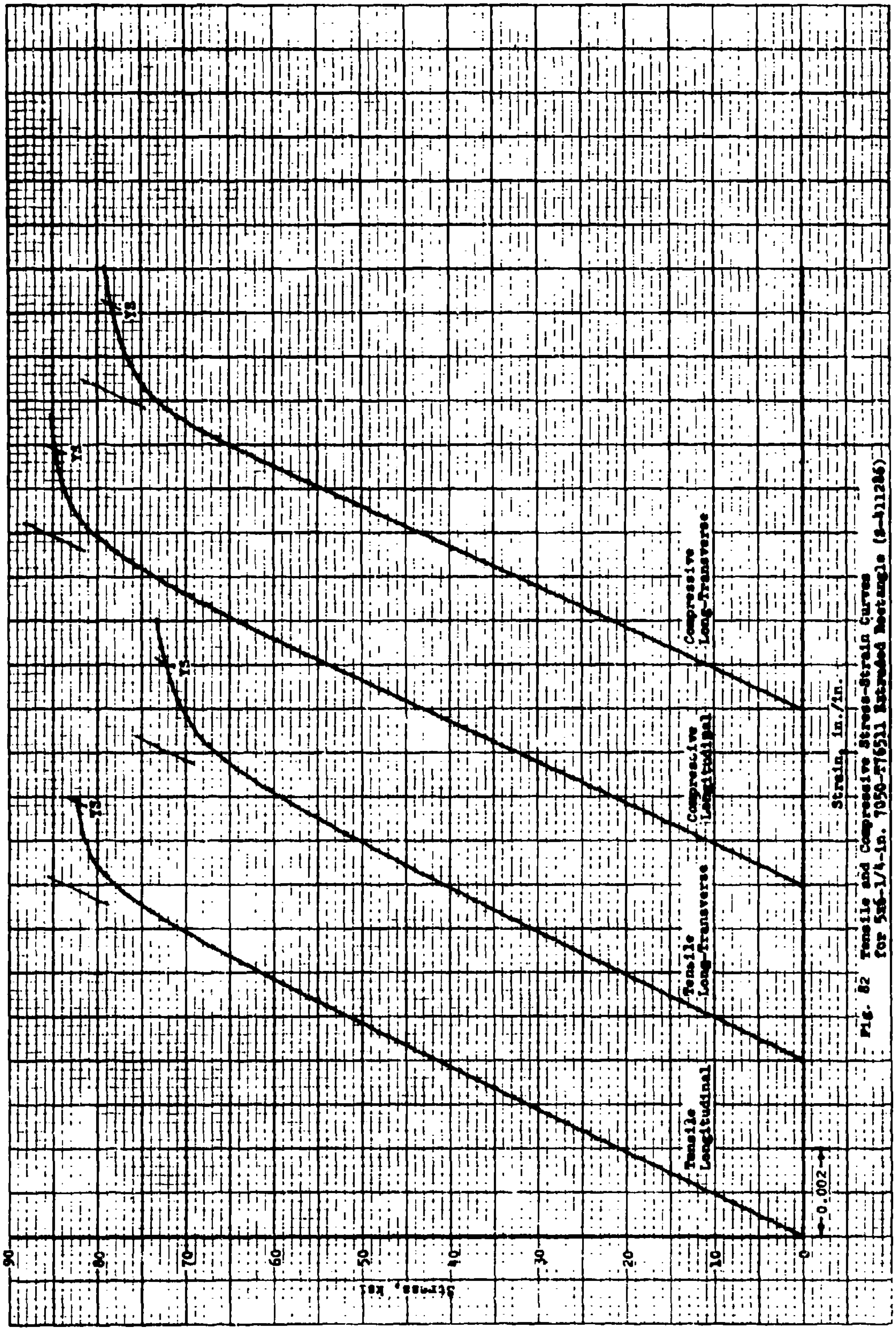


Fig. 82 Tensile and Compressive Stress-Strain Curves for 5x6-1/4-in. 7050-T76511 Extruded Rectangle (S-411286)

Fig. 82

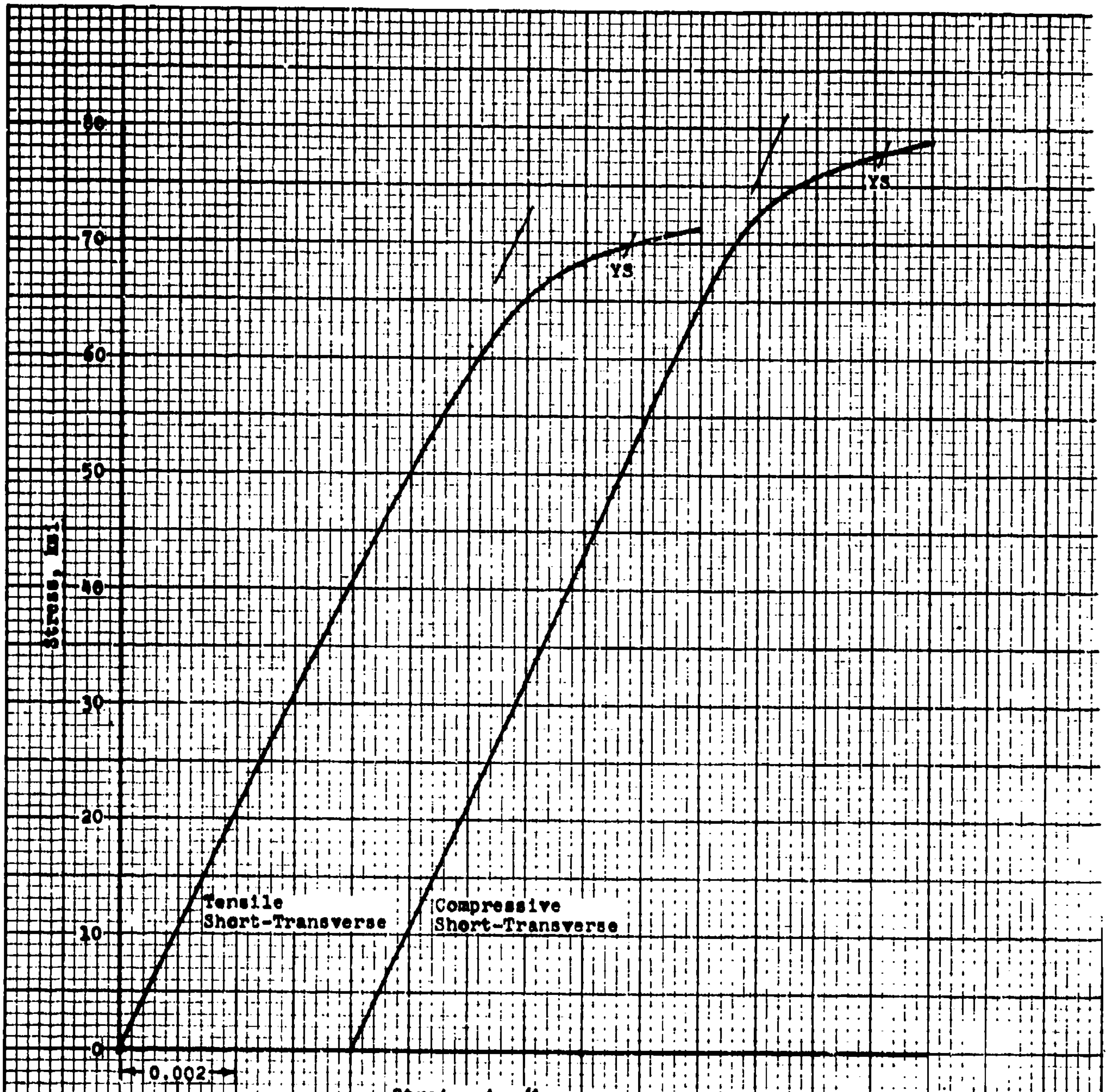


Fig. 83 Tensile and Compressive Stress-Strain Curves for 5x6-1/4-in. 7050-T76511 Extruded Rectangle (S-411286)

Fig. 83

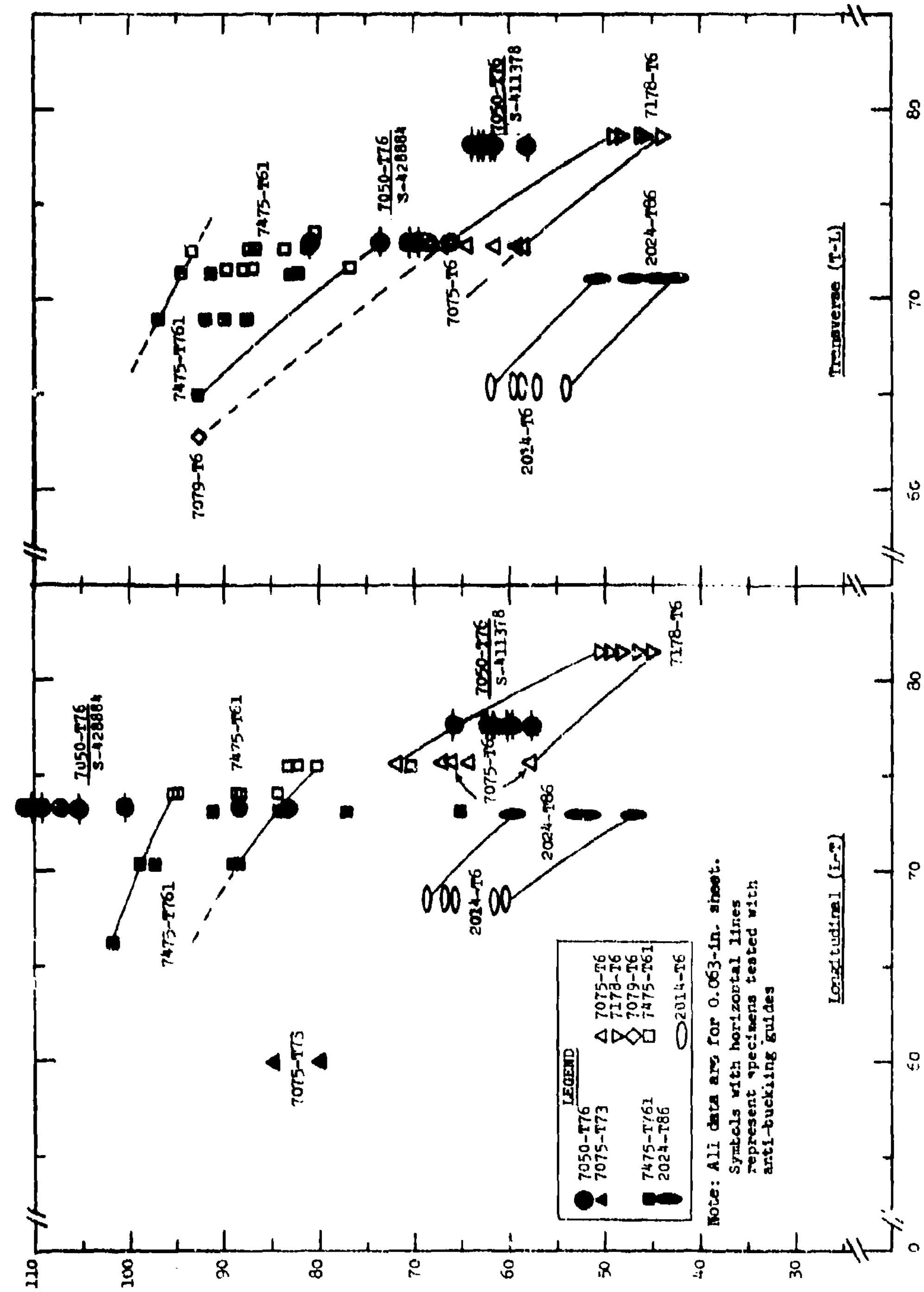


Fig. 84 K_c vs. Tensile Yield Strength of 0.063-in. Sheet

Fig. 84

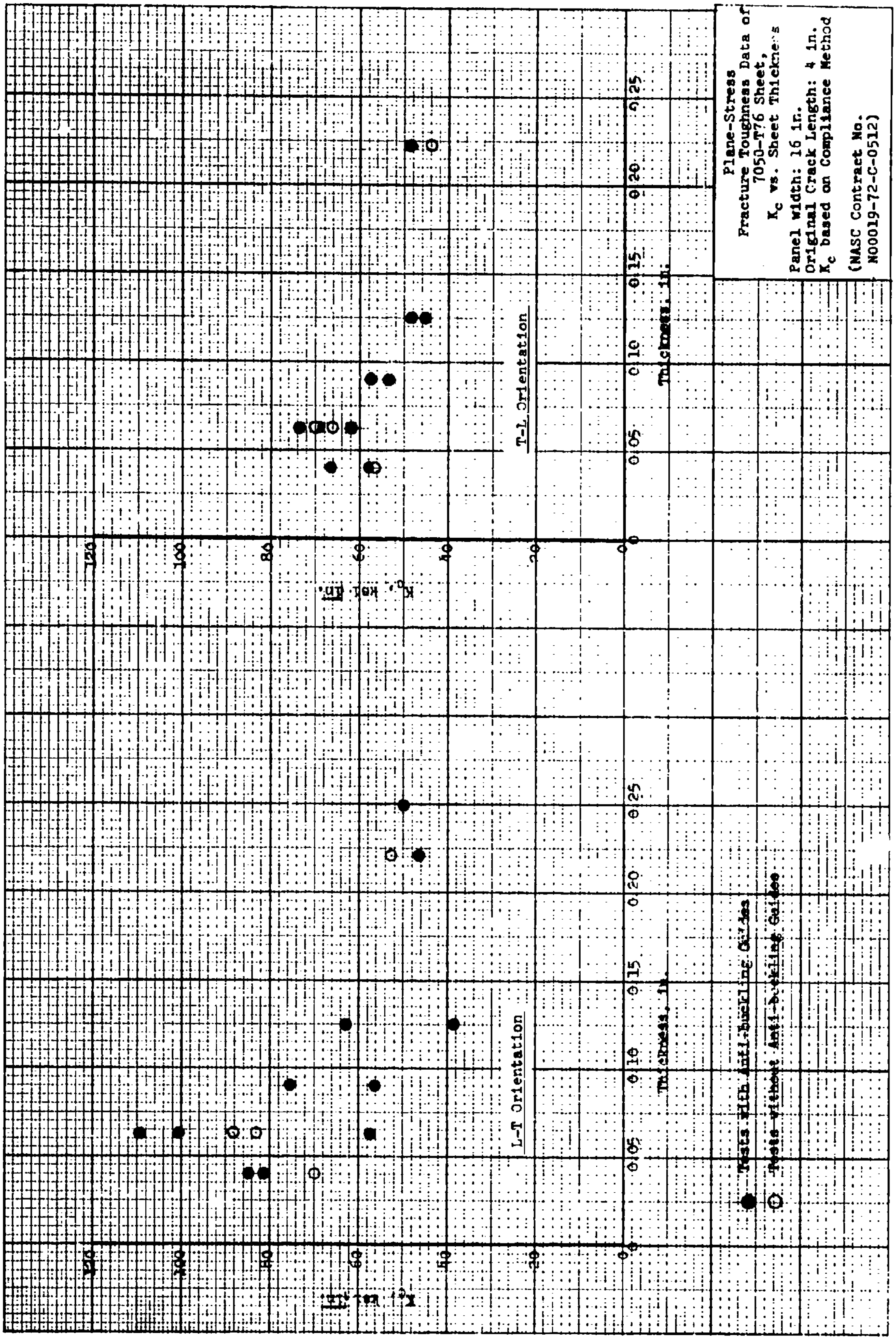
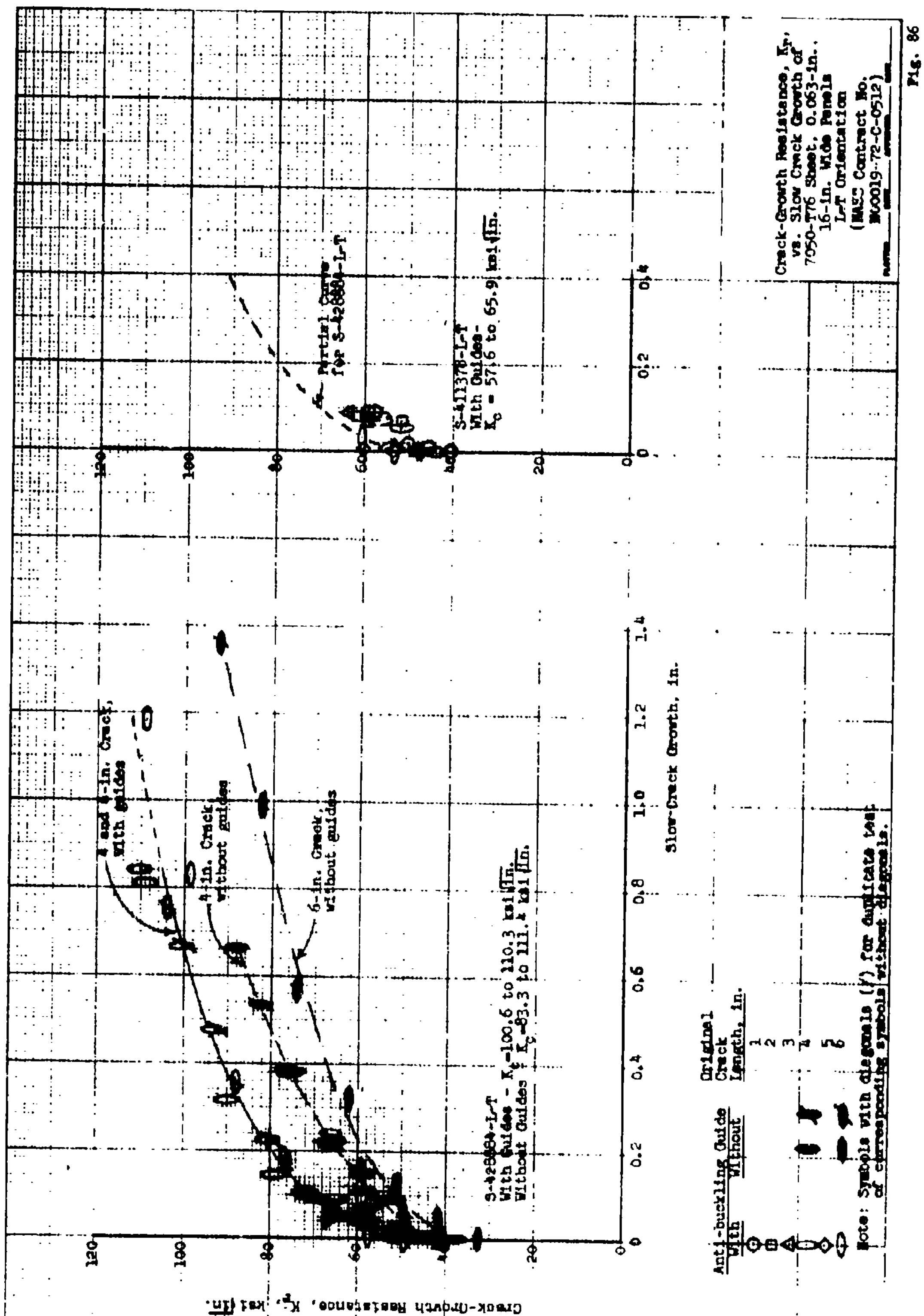

Plane-Stress
Fracture Toughness Data of 7050-T76 Sheet,
K_c vs. Sheet Thickness
Panel width: 16 in.
Original Crack Length: 4 in.
K_c based on Compliance Method
(NASC Contract No. N00019-72-C-0512)
Fig. 85
T-L Orientation
L-T Orientation
Thickness, in.
K_c, ksi $\sqrt{\text{in.}}$
0
0.05
0.10
0.15
0.20
0.25
20
40
60
80
100
120
Tests With Anti-Buckling Guides
Tests without Anti-Buckling Guides

Fig. 85



Crack-Growth Resistance, K_R, vs. Slow Crack Growth of 7050-T76 Sheet, 0.063-in., 16-in. Wide Panels L-T Orientation (NAVAIR Contract No. N00019-72-C-0512)
Fig. 86
Crack-Growth Resistance, K_R, ksi√in.
Slow-Crack Growth, in.
S-42884-L-T
With Guides - K_c=100.6 to 110.3 ksi√in.
Without Guides - K_c=83.3 to 111.4 ksi√in.
4 and 6-in. Crack, with guides
4-in. Crack, without guides
6-in. Crack, without guides
S-411378-L-T
With Guides-
K_c = 57.6 to 65.9 ksi√in.
Partial Curve for S-42884-L-T
Anti-buckling Guide
With
Without
Original Crack Length, in.
1
2
3
4
5
6
Note: Symbols with diagonals (/) for duplicate test of corresponding symbols without diagonals.

Fig. 86

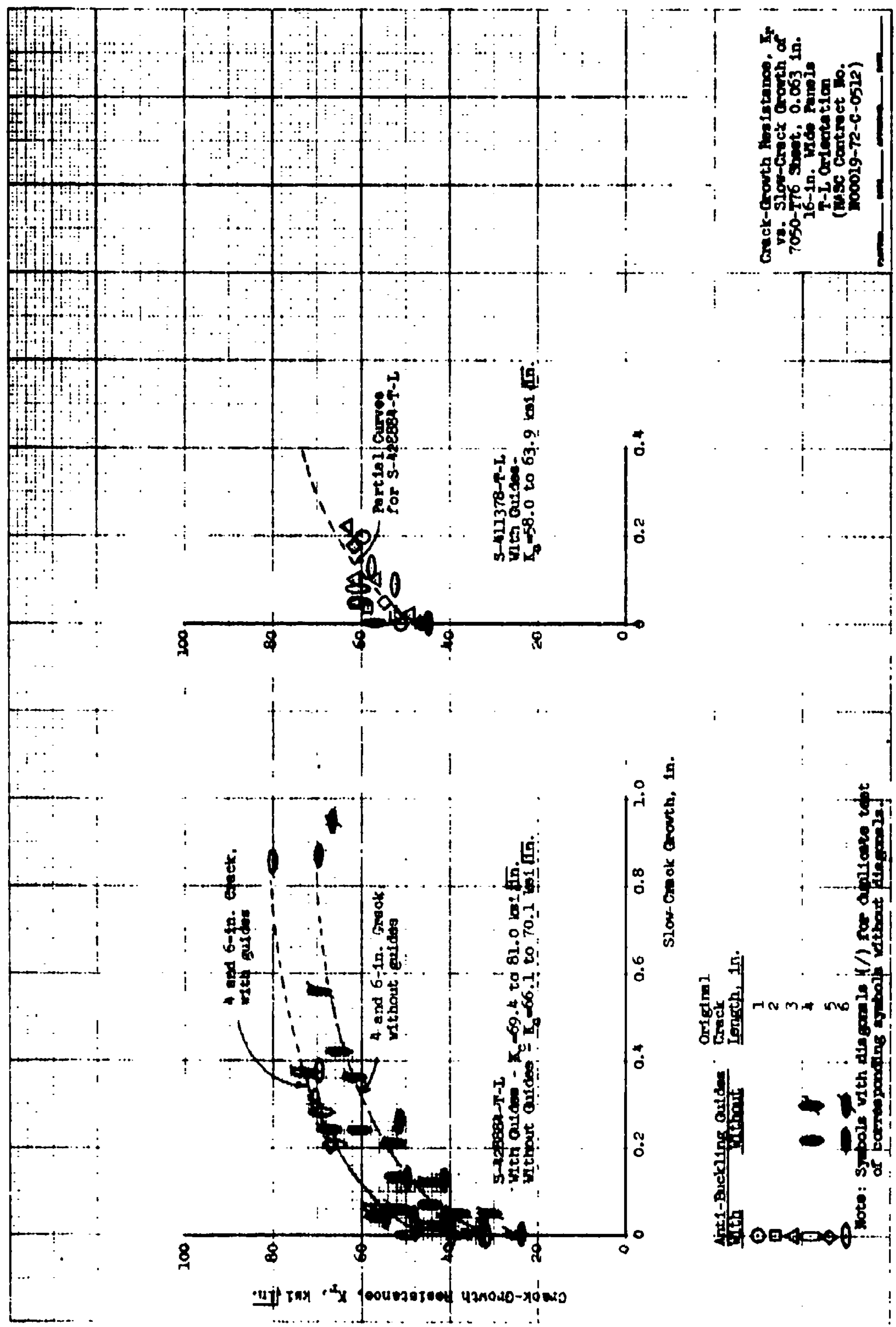
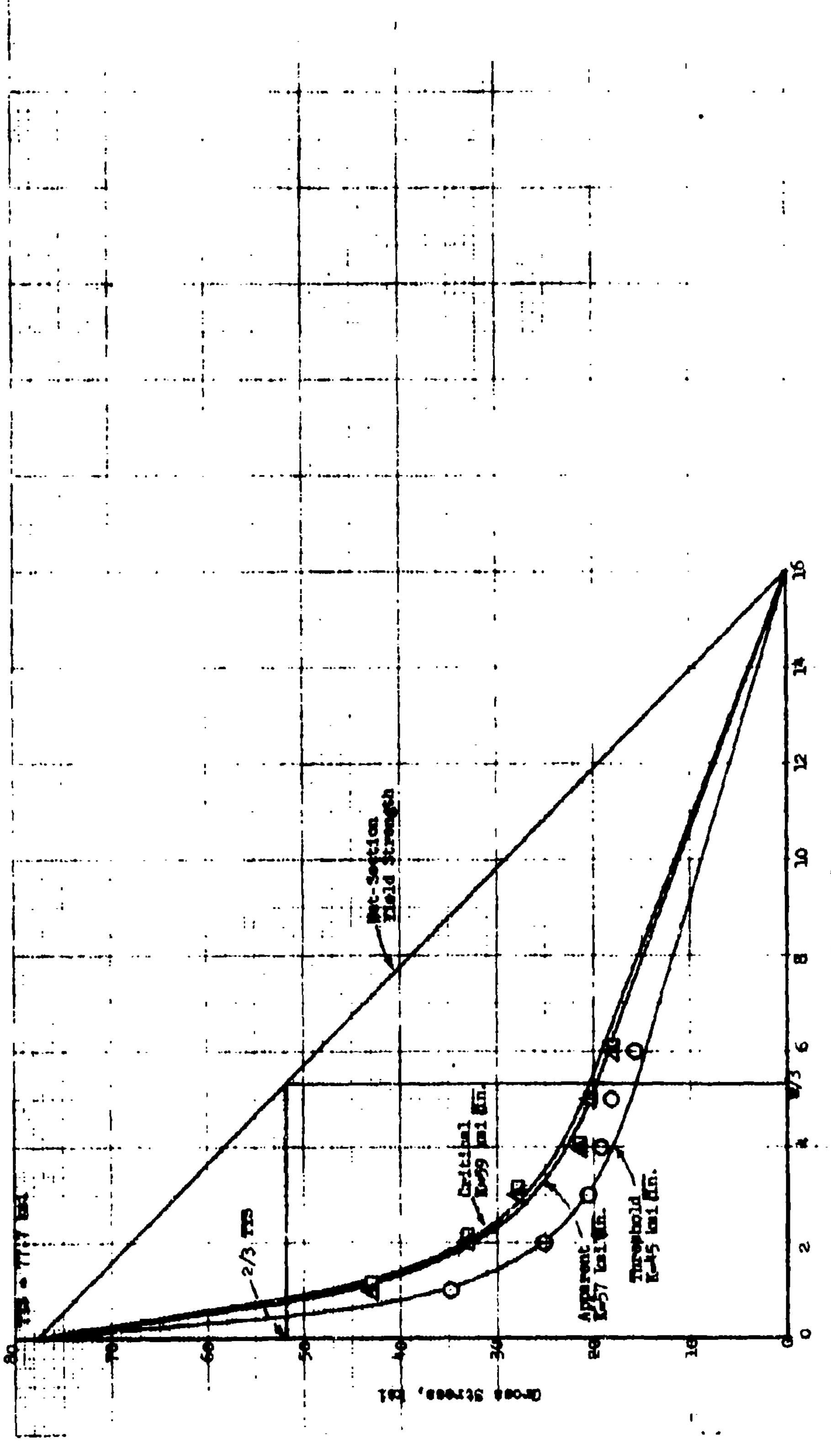

Crack-Growth Resistance, K_r, vs. Slow-Crack Growth of 7050-T76 Sheet, 0.063 in. 16-in. Wide Panels T-L Orientation (NASC Contract No. N00019-72-C-0512)
Fig. 87
Crack-Growth Resistance, K_r, ksi $\sqrt{in.}$
Slow-Crack Growth, in.
S-428884-T-L
With Guides - K_c=69.4 to 81.0 ksi $\sqrt{in.}$
Without Guides - K_c=66.1 to 70.1 ksi $\sqrt{in.}$
4 and 6-in. Crack with guides
4 and 6-in. Crack without guides
S-411378-T-L
With Guides-
K_c=58.0 to 63.9 ksi $\sqrt{in.}$
Partial Curves for S-428884-T-L
Anti-Buckling Guides
With
Without
Original Crack Length, in.
1
2
3
4
5
6
Note: Symbols with diagonals (/) for duplicate test of corresponding symbols without diagonals.

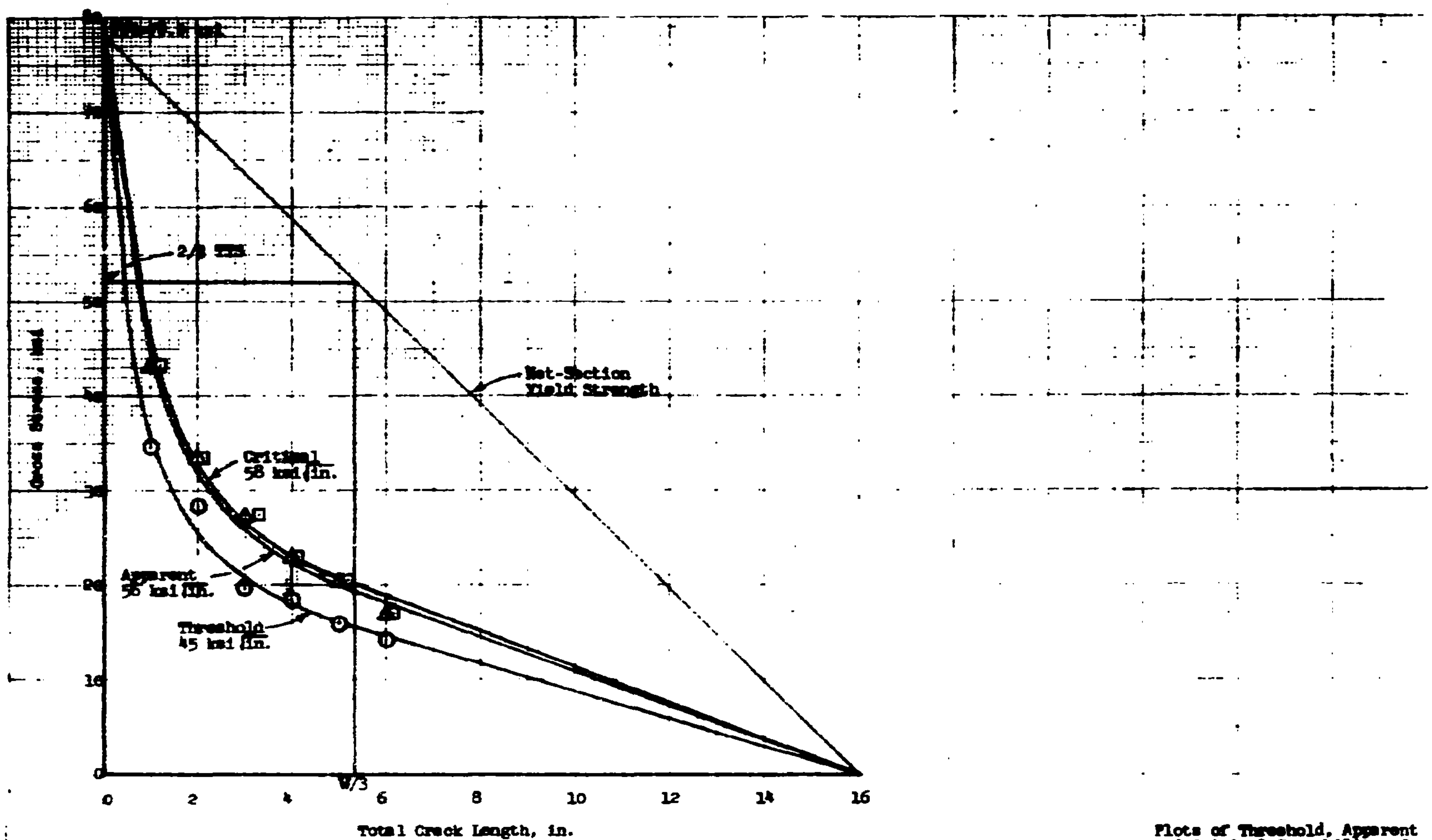
Fig. 87



Plots of Threshold, Apparent and Critical Instability of 7050-T76 Sheet, 0.063-in. 16-in. Wide Panels L-T Orientation

(NASC Contract No. N00019-72-C-0512)

Fig. 88



Plots of Threshold, Apparent and Critical Instability of 7050-T76 Sheet, 0.063-in. 16-in. Wide Panels T-L Orientation

(NASC Contract No. N00019-72-C-0512)

Fig. 89

Fig. 89

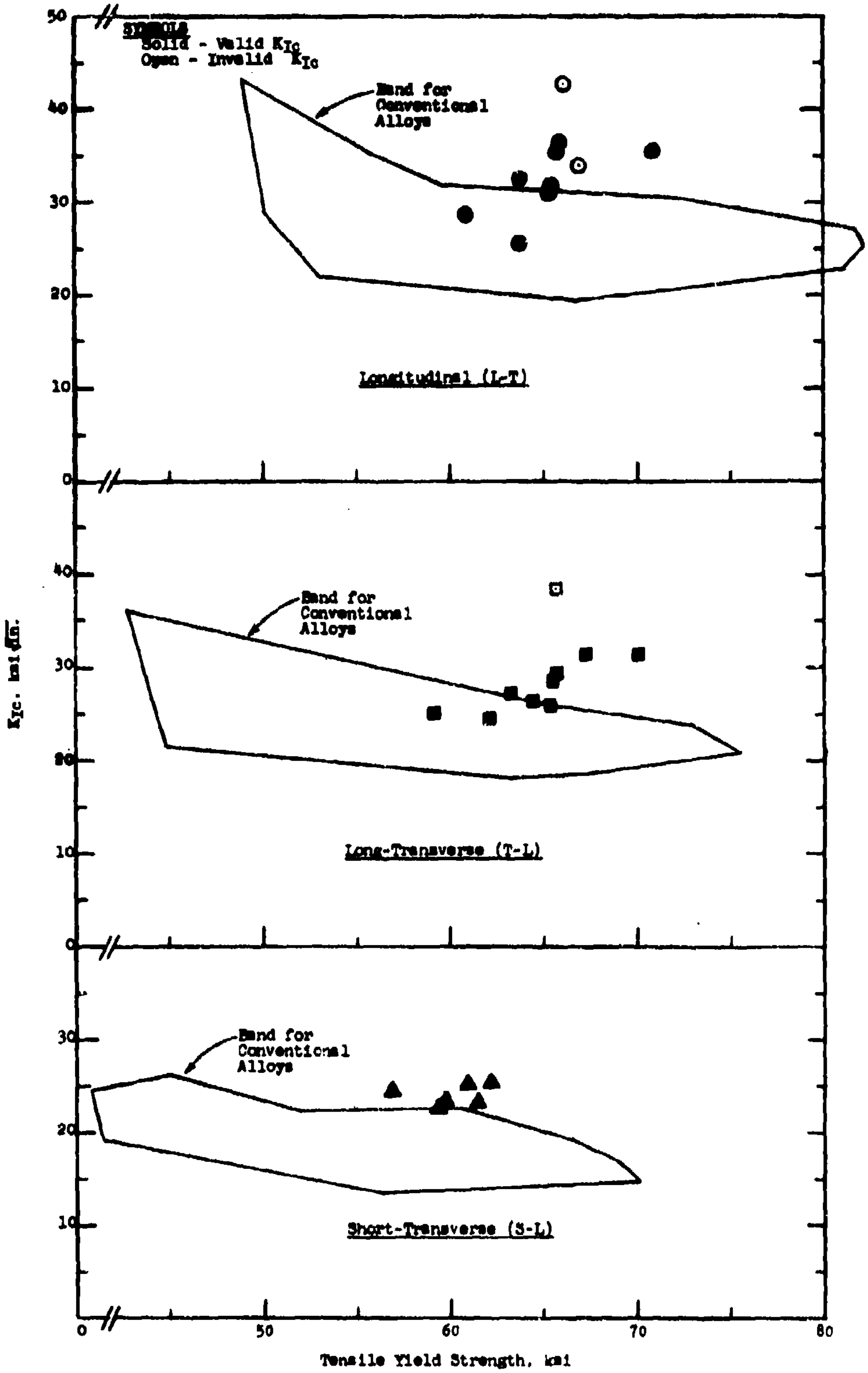


Fig. 90 K_{Ic} Vs. Tensile Yield Strength of 7050-T73651 Plate, Thickness: 1/2 to 6 in.

Fig. 90

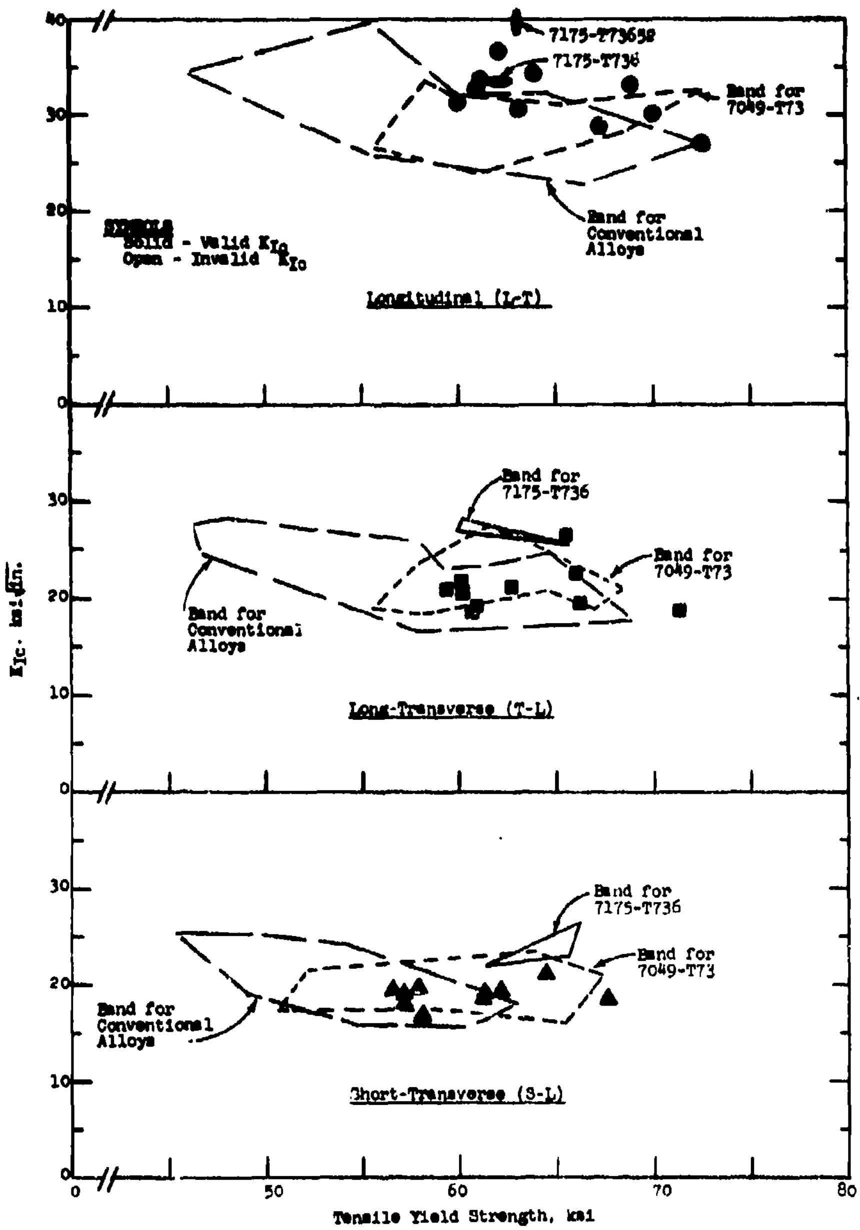


Fig. 91 K_{Ic} Vs. Tensile Yield Strength of 7050-T73652 Hand Forgings, Thickness: 2 to 7-1/2 In.

Fig. 91

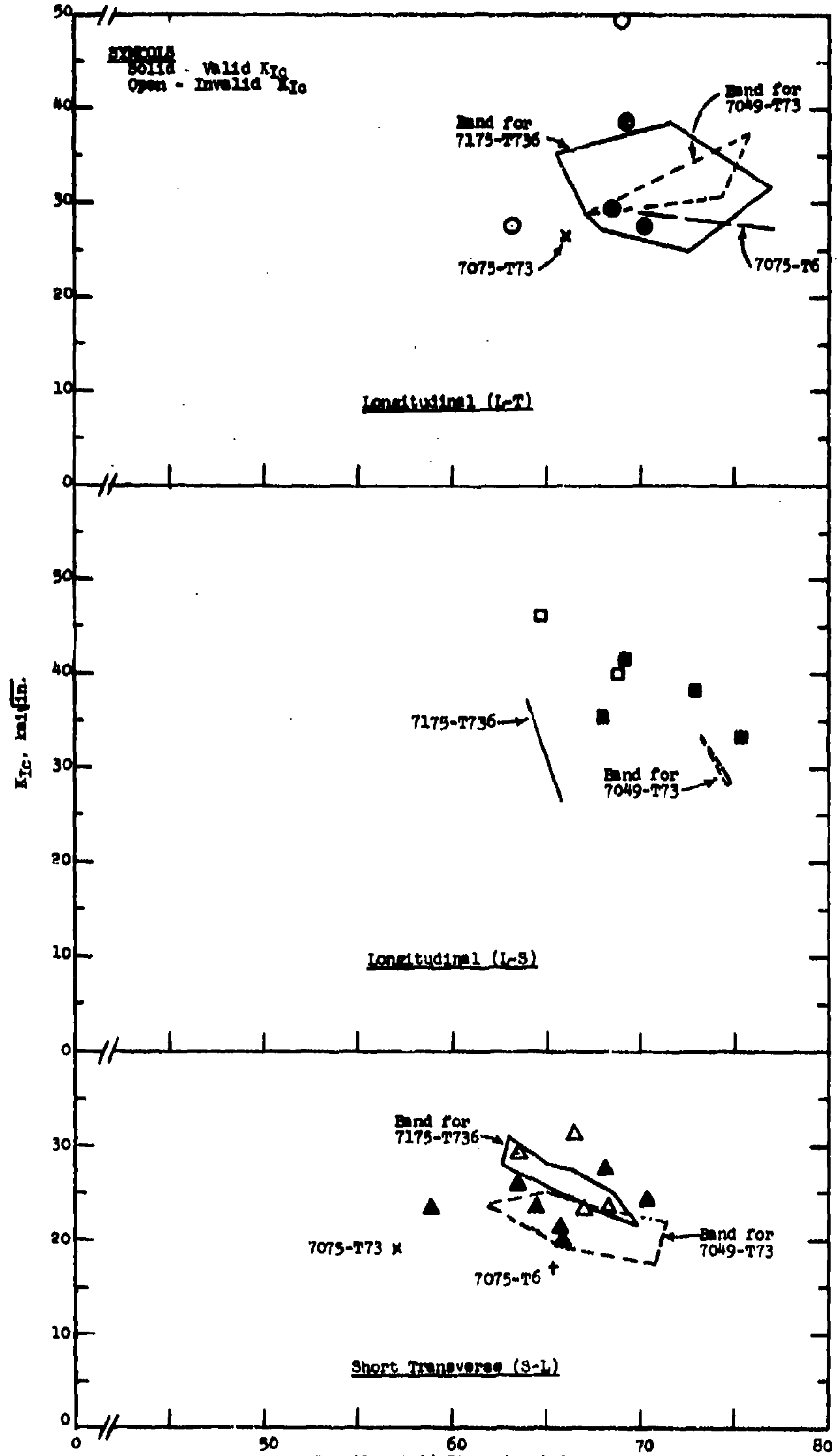


Fig. 92 K_{Ic} Vs. Tensile Yield Strength of 7050-T736 Die Forgings, Thickness: 0.6 to 6.1 in.

Fig. 92

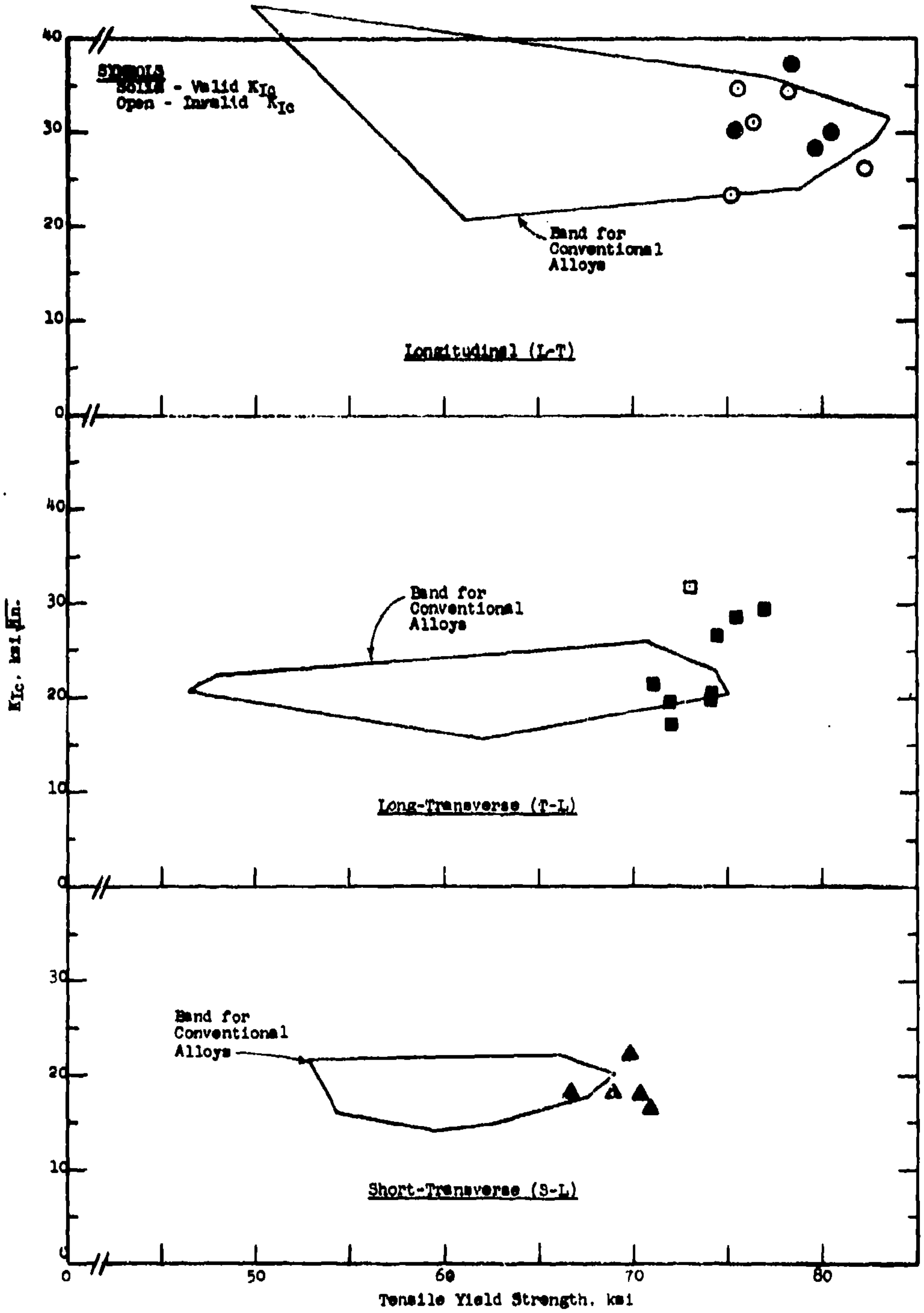


Fig. 93 K_{Ic} Vs. Tensile Yield Strength of 7050-T76511 Extruded Shapes Thickness: 0.4 to 5 in.

Fig. 93

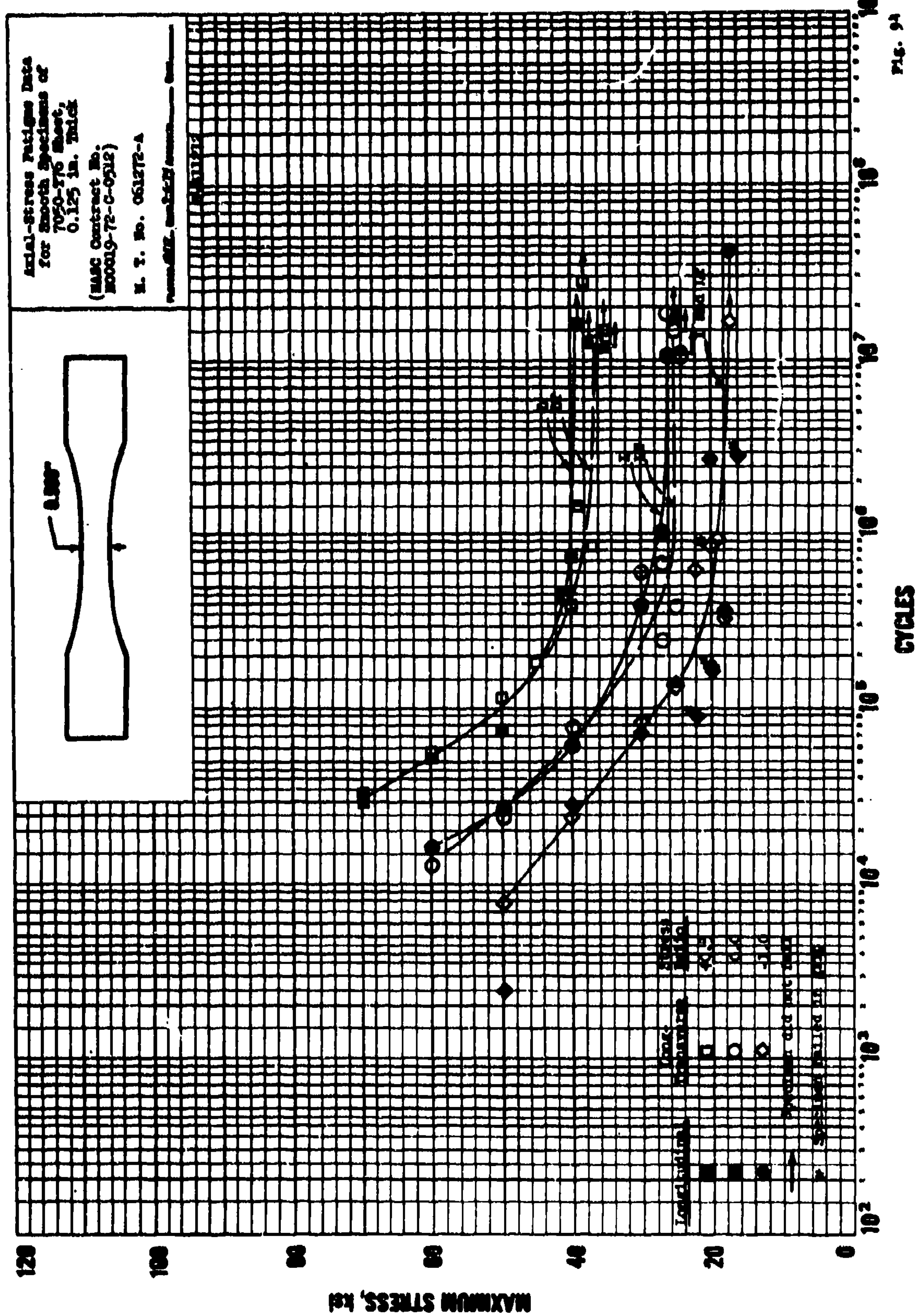


Fig. 94

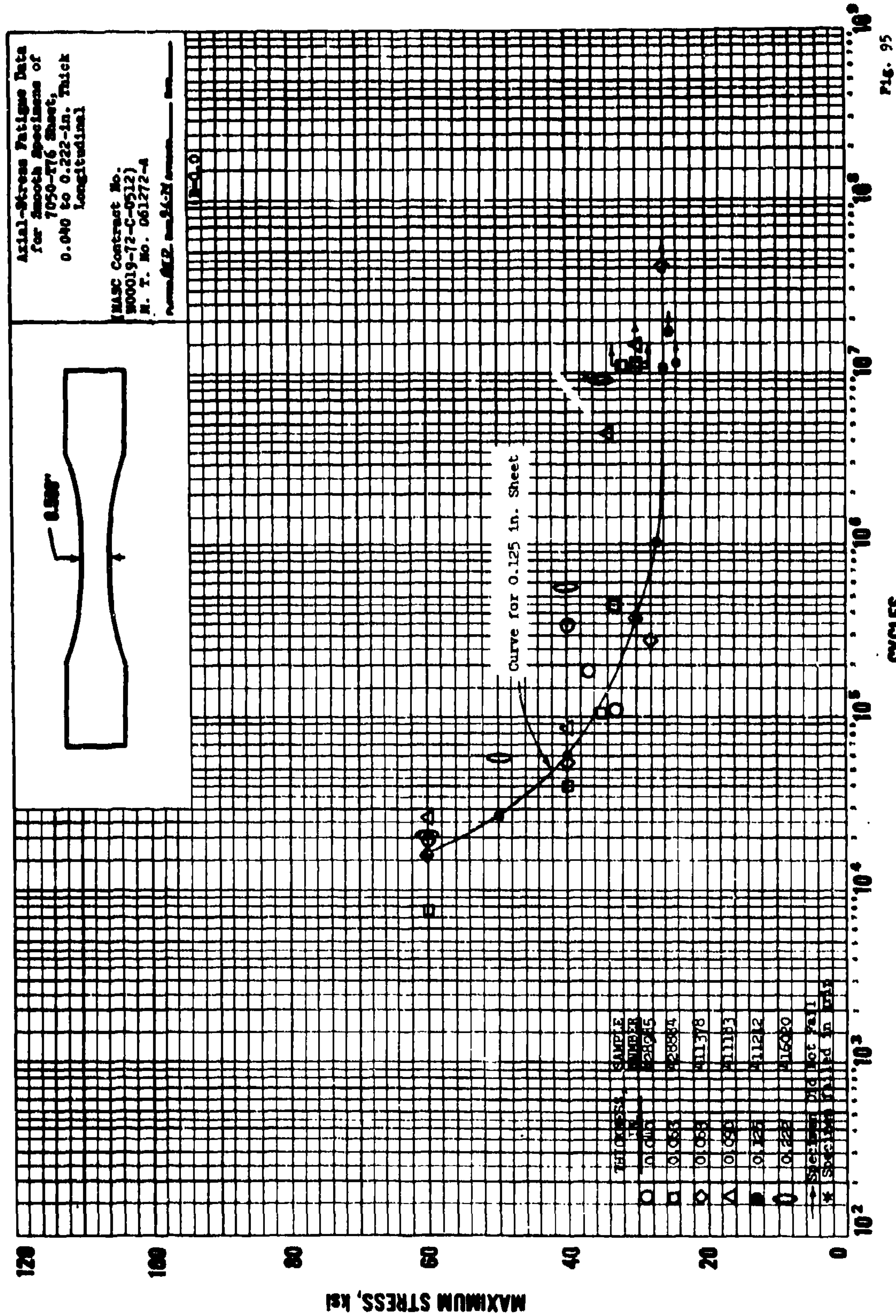
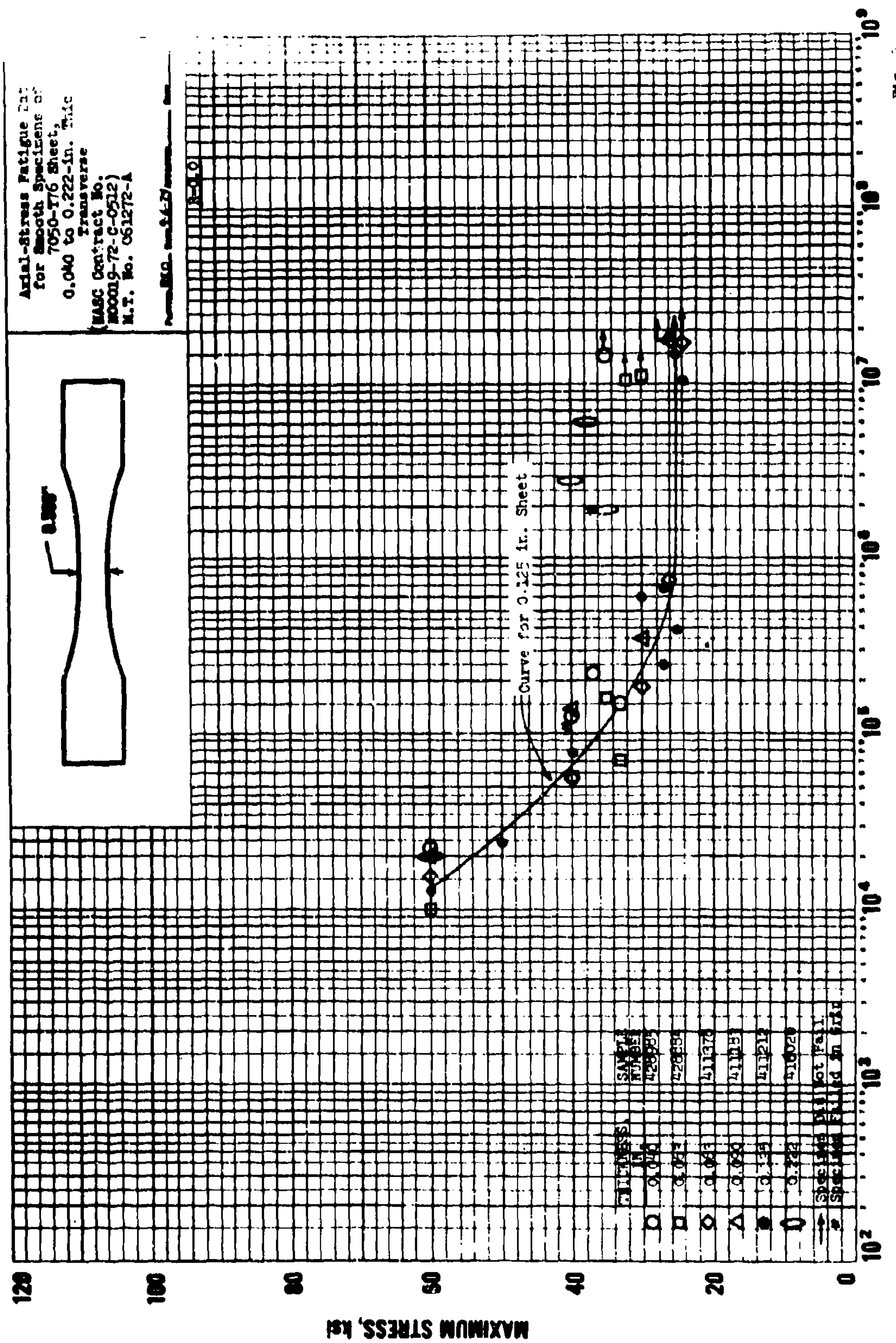

Axial-Stress Fatigue Data for Smooth Specimens of 7050-T76 Sheet, 0.040 to 0.222-in. Thick Longitudinal
Curve for 0.125 in. Sheet
CYCLES
MAXIMUM STRESS, ksi
Fig. 95

Fig. 95



7050-T76 Sheet,
0.040 to 0.222-in.
Transverse
NAVC Contract No.
N00019-72-C-0512)
M.T. No. 061272-A
Curve for 0.125 in. Sheet
MAXIMUM STRESS, ksi
CYCLES

Fig. 96

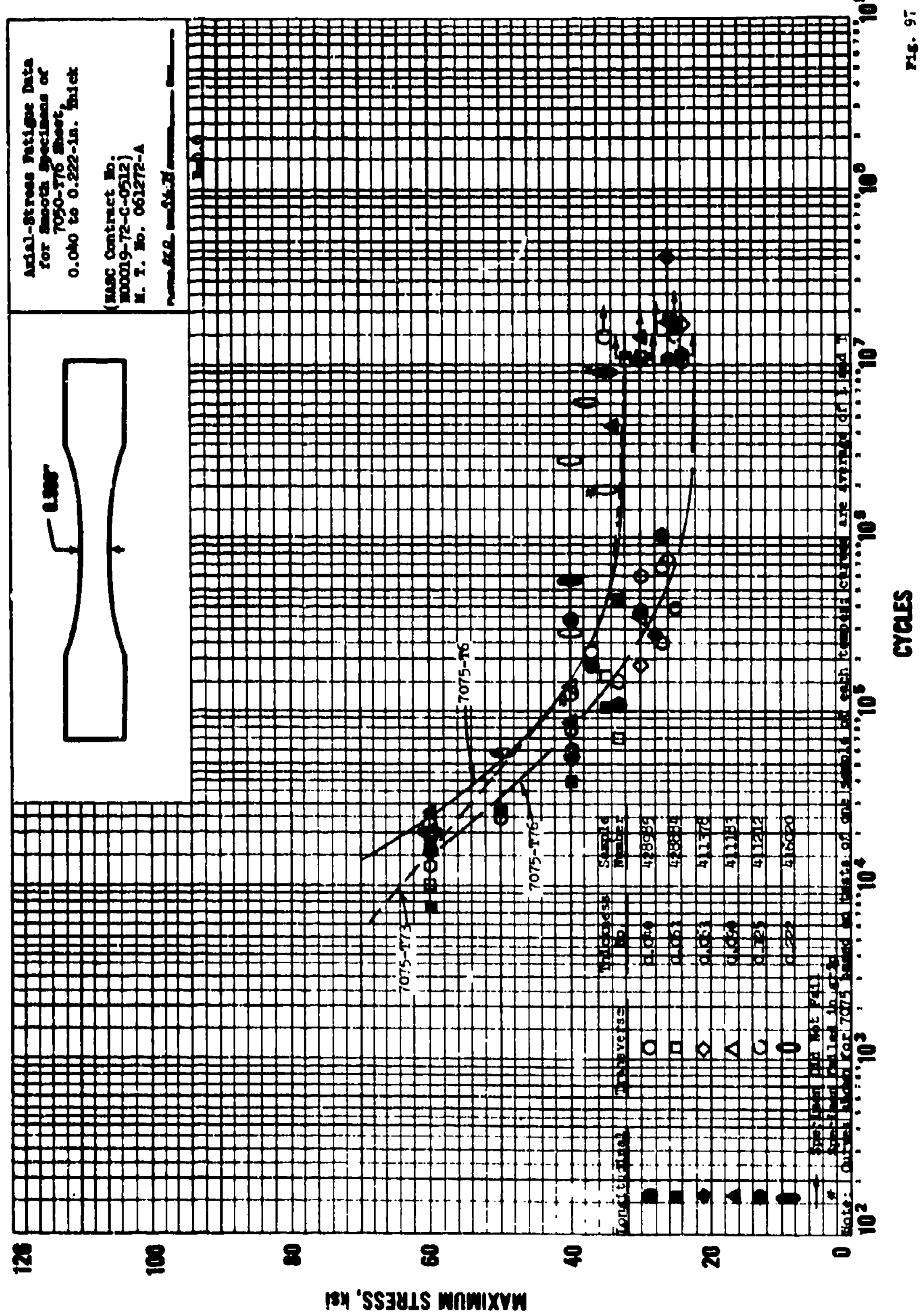

Axial-Stress Fatigue Data
for Smooth Specimens of
7050-T76 Sheet,
0.040 to 0.222-in. Thick
(NASC Contract No.
N00019-72-C-0512)
M. T. No. 061272-A
7075-T6
7075-T76
7075-T73
Longitudinal
Transverse
Thickness
Sample
Number
0.040
0.061
0.063
0.064
0.125
0.222
428859
428884
411378
411383
411212
416020
→ Specimen Did Not Fail
MAXIMUM STRESS, ksi
CYCLES
Fig. 97

Fig. 97

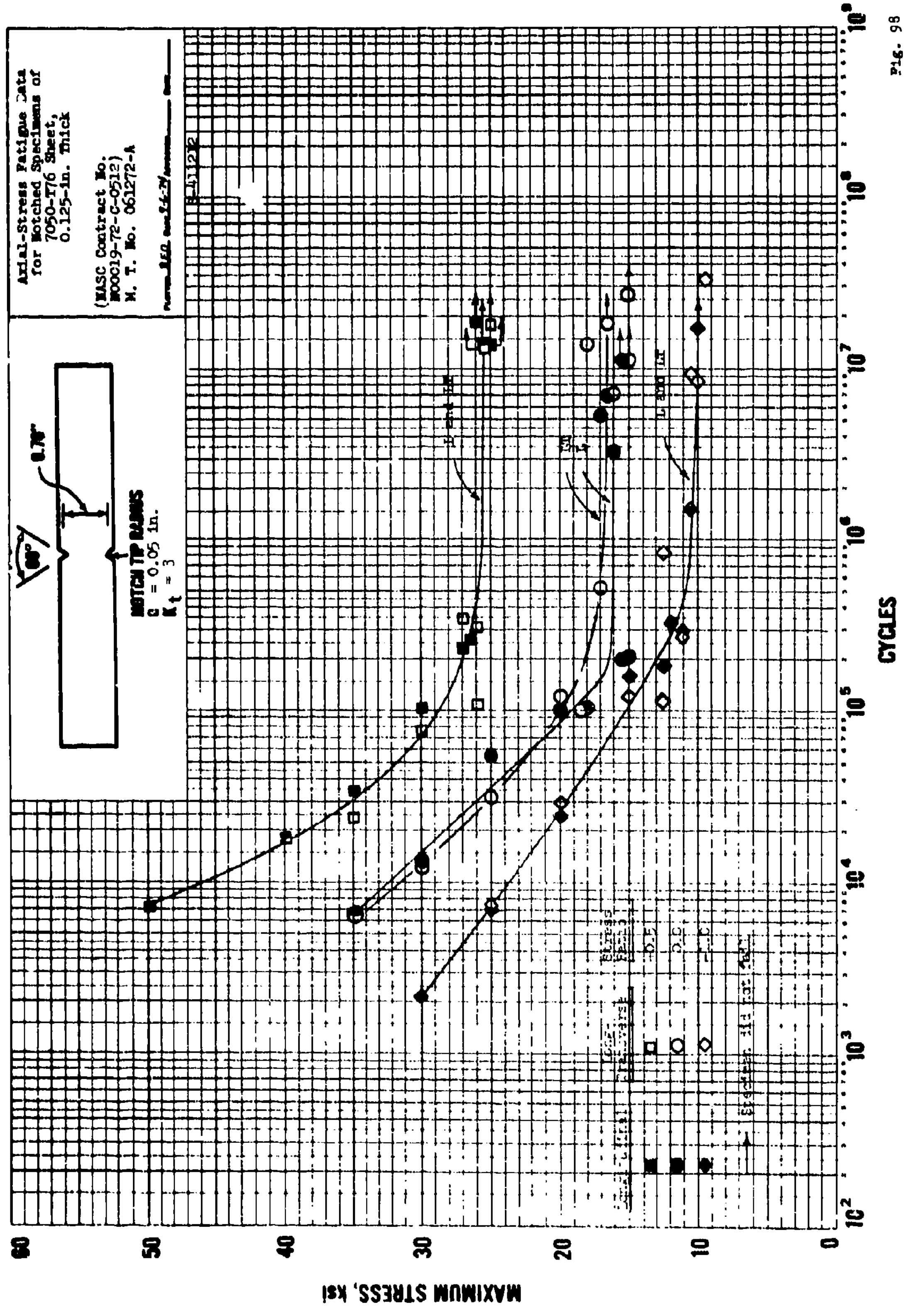
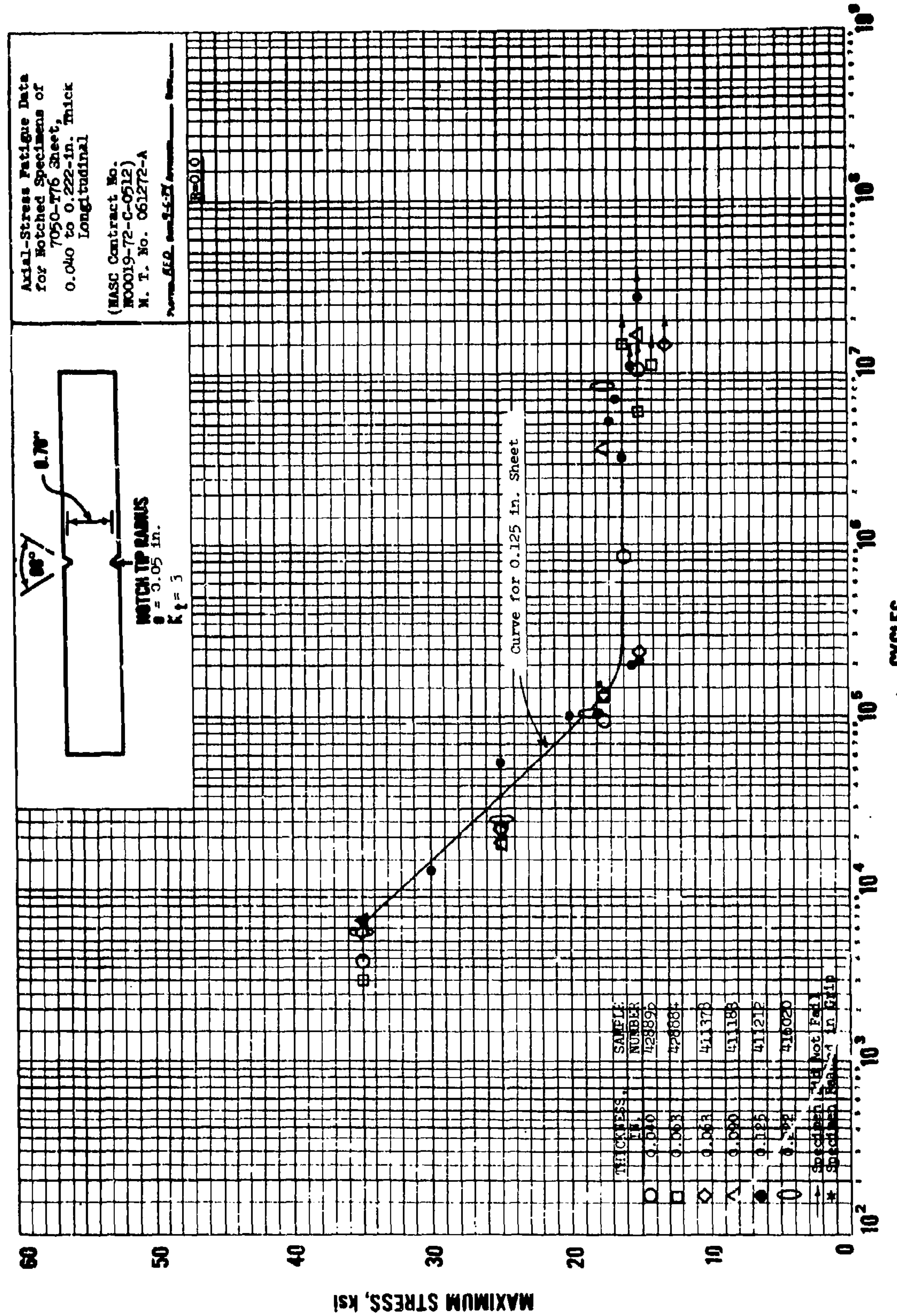

Axial-Stress Fatigue Data
for Notched Specimens of
7050-T76 Sheet,
0.125-in. Thick
(NASC Contract No.
N00019-72-C-0512)
M. T. No. 061272-A
NOTCH TIP RADIUS
0.05 in.
K_t = 3
60°
0.70"
MAXIMUM STRESS, ksi
CYCLES

Fig. 98



Axial-Stress Fatigue Data for Notched Specimens of 7050-T76 Sheet, 0.040 to 0.222-in. Thick Longitudinal
(NASC Contract No. N00019-72-C-0512)
M. T. No. 061272-A
0.70"
NOTCH TIP RADIUS
= 0.05 in.
K_t = 3
Curve for 0.125 in. Sheet
THICKNESS, IN.
SAMPLE NUMBER
0.040
0.063
0.063
0.090
0.125
Specimen Did Not Fail
MAXIMUM STRESS, ksi
CYCLES
Fig. 99

Fig. 99

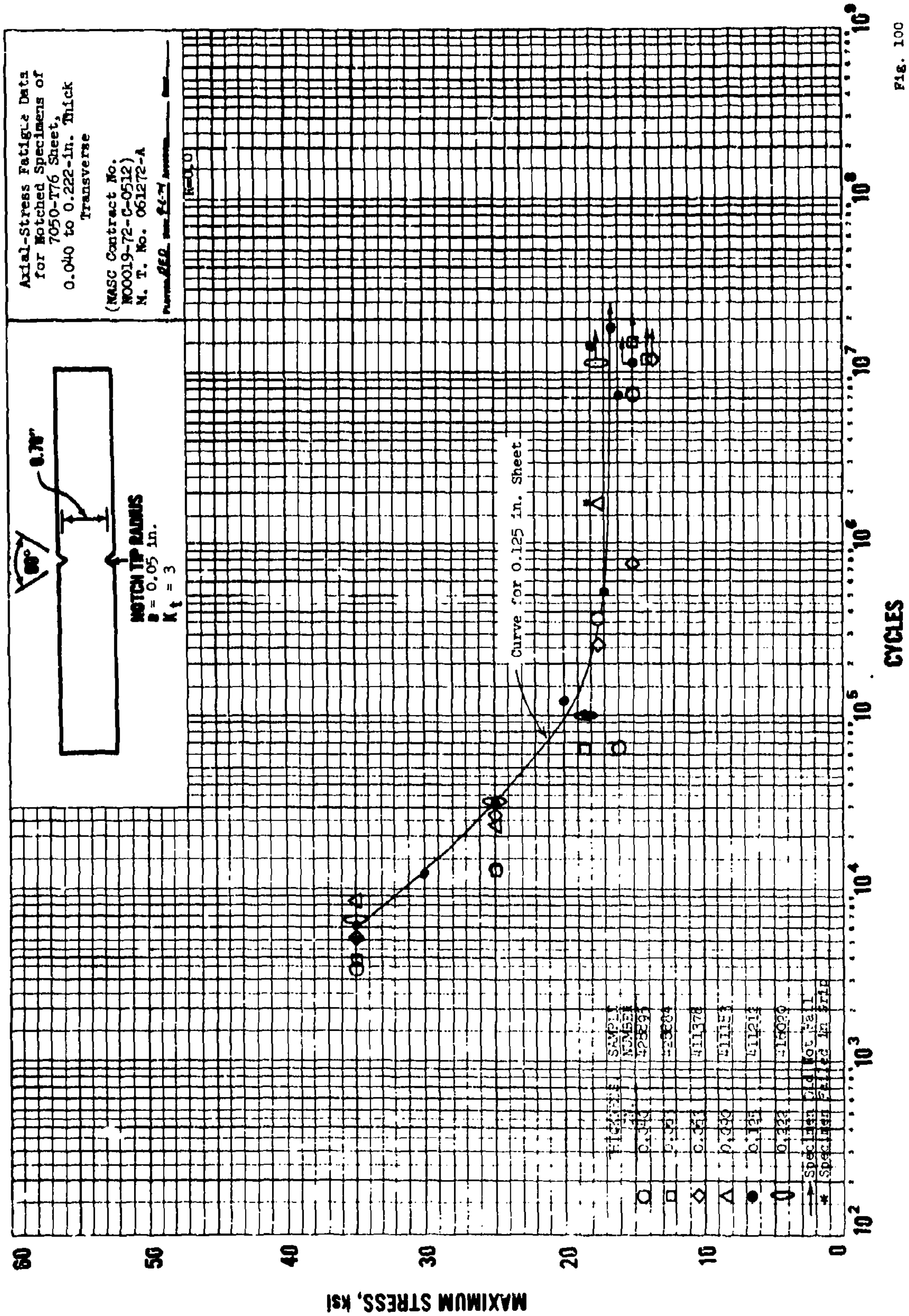
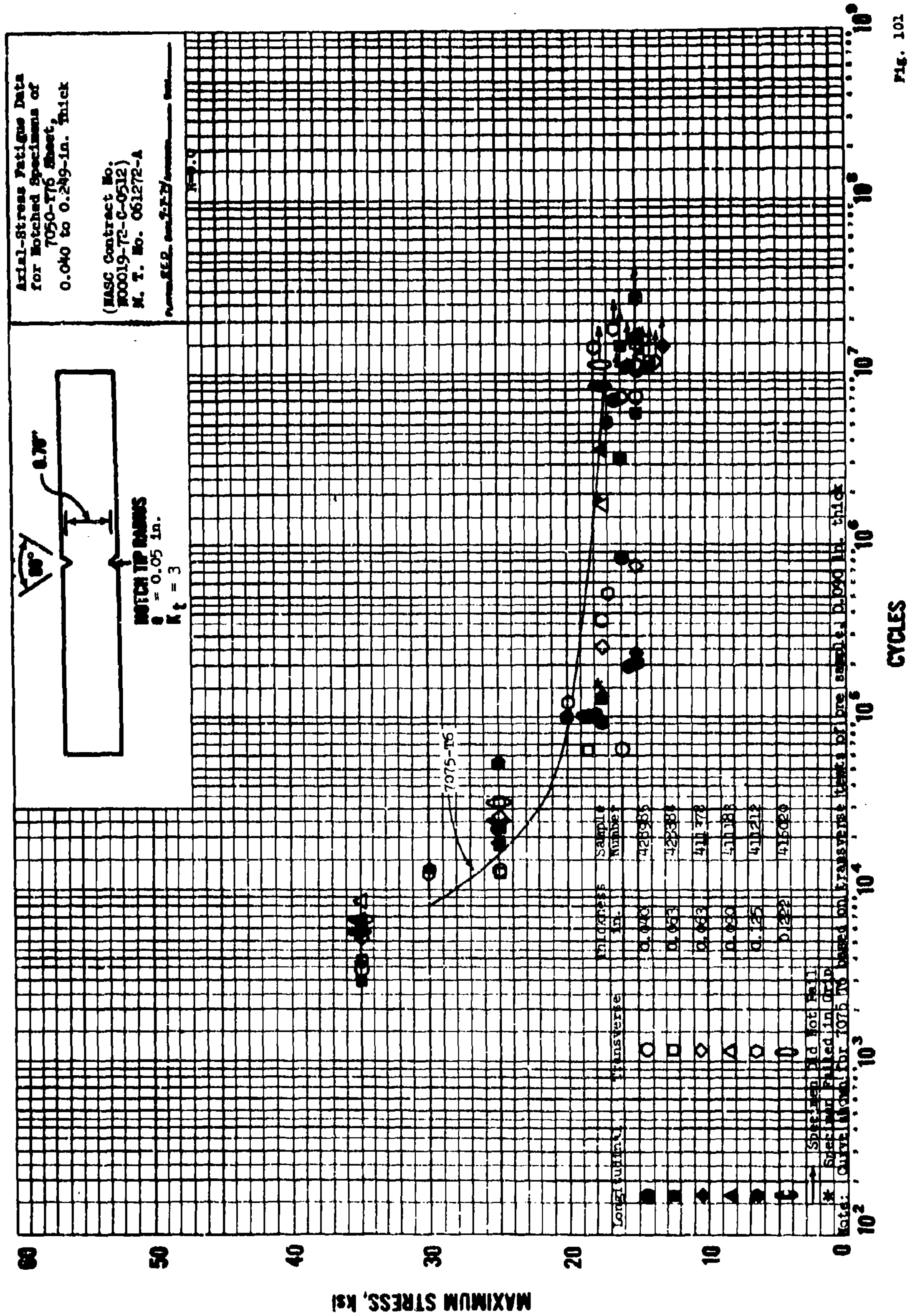
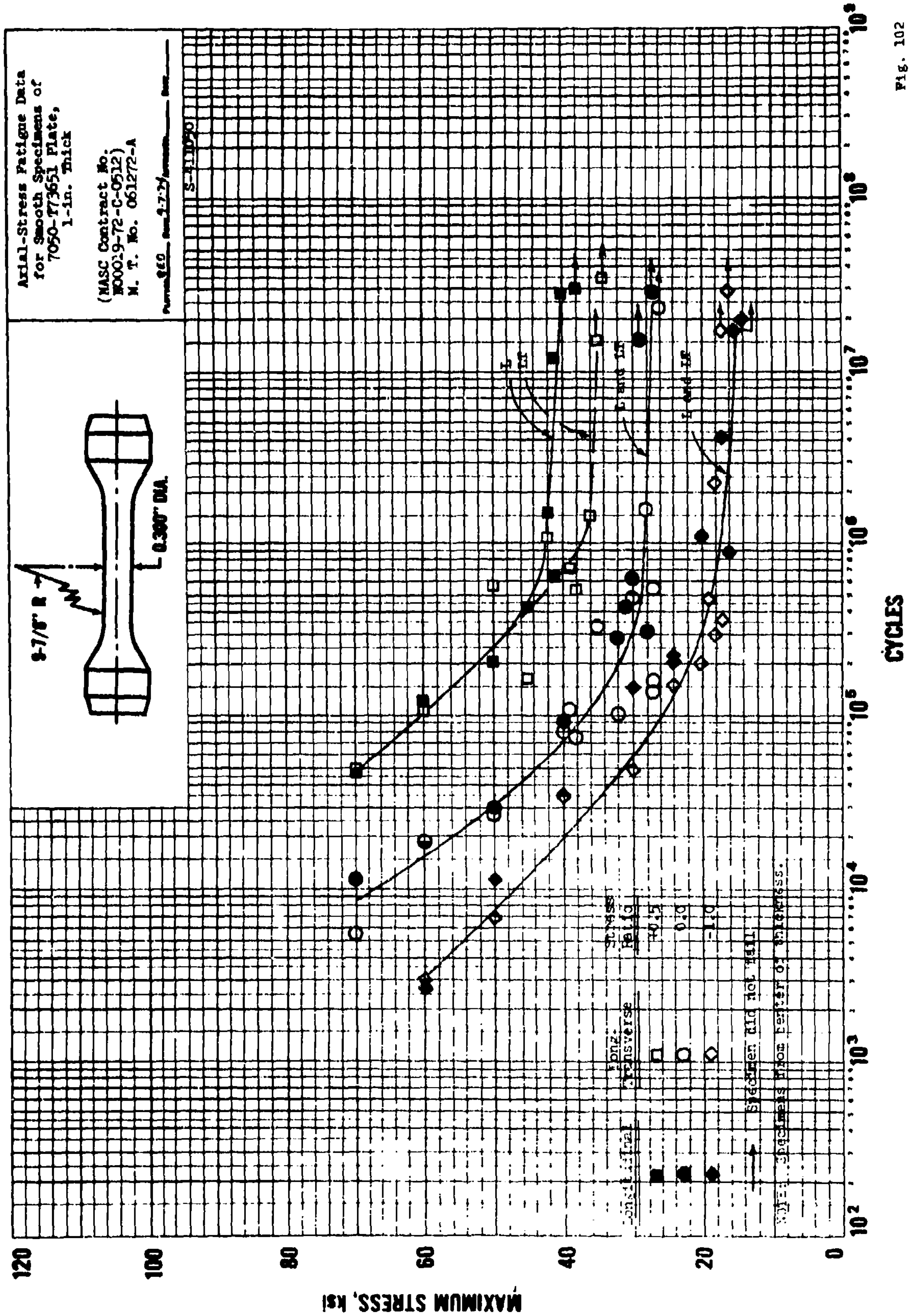

Axial-Stress Fatigue Data for Notched Specimens of 7050-T76 Sheet, 0.040 to 0.222-in. Thick Transverse
(NASC Contract No. N00019-72-C-0512)
N. T. No. 061272-A
NOTCH TIP RADIUS
= 0.05 in.
Kt = 3
60°
Curve for 0.125 in. Sheet
MAXIMUM STRESS, ksi
CYCLES
Fig. 100

Fig. 100



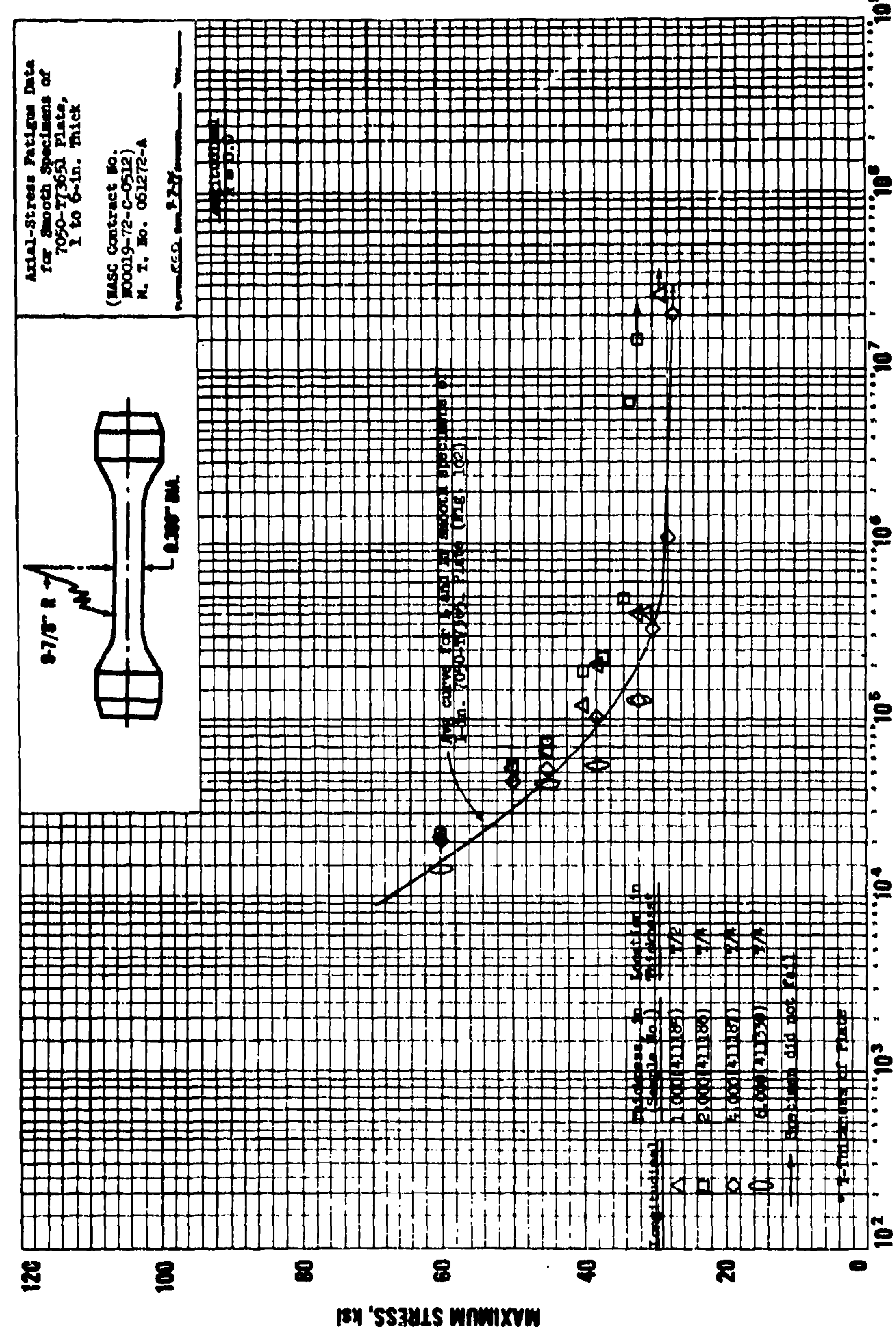
Axial-Stress Fatigue Data for Notched Specimens of 7050-T76 Sheet, 0.040 to 0.249-in. Thick
(NASC Contract No. N00019-72-C-0512)
M. T. No. 061272-A
NOTCH TIP RADIUS
ρ = 0.05 in.
K_t = 3
7075-T6
Longitudinal
Transverse
Thickness in.
Sample Number
Specimen Did Not Fail
Specimen Failed in Grip
MAXIMUM STRESS, ksi
CYCLES
Fig. 101

Fig. 101



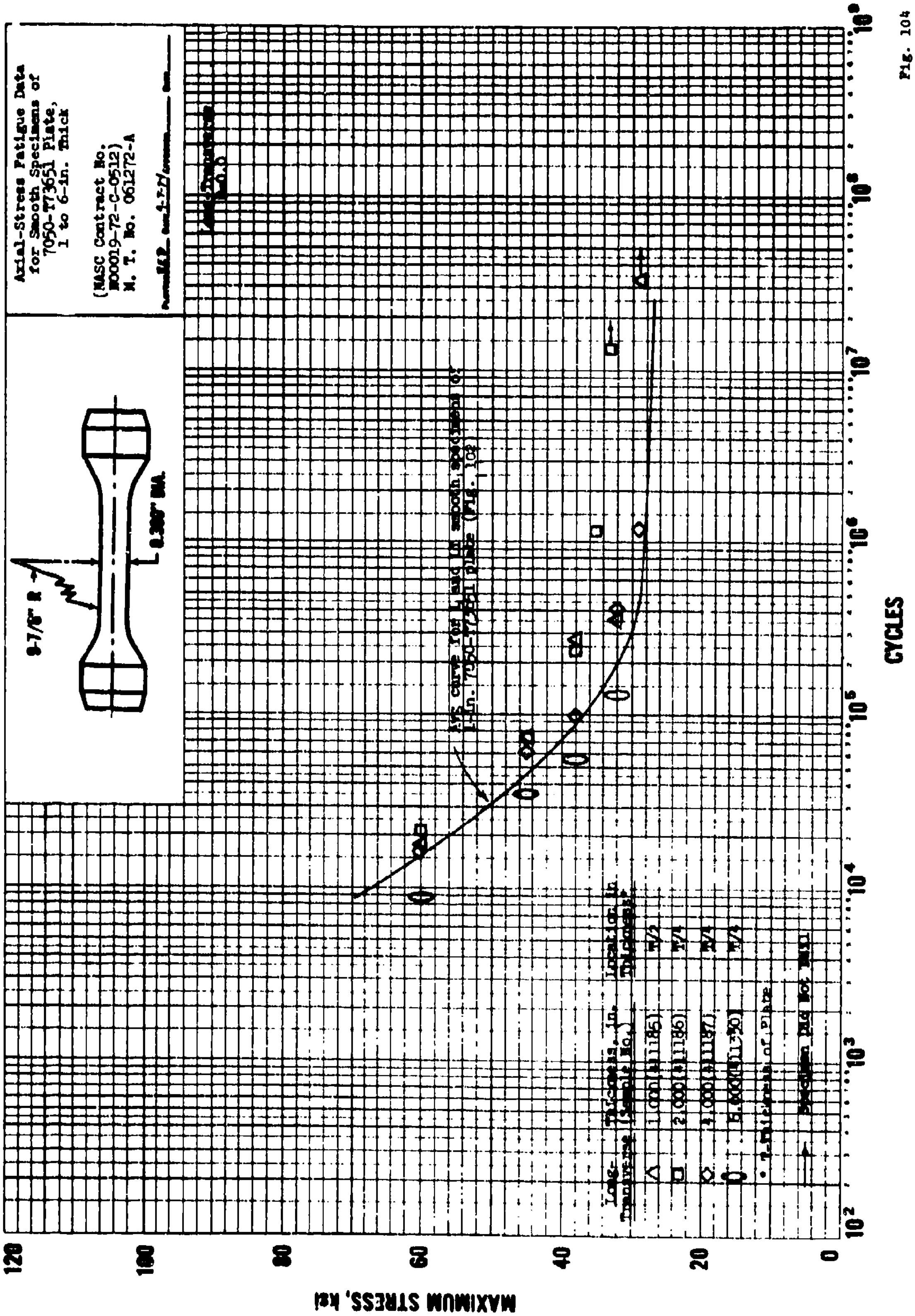
Axial-Stress Fatigue Data
for Smooth Specimens of
7050-T73651 Plate,
1-in. Thick
(NASC Contract No.
N00019-72-C-0512)
M. T. No. 061272-A
S-411090
9-7/8" R
0.300" DIA.
L
LT
L and LT
L and LT
Longitudinal
Long-Transverse
Stress Ratio
+0.5
0.0
-1.0
Specimen did not fail
Note: Specimens taken from center of thickness.
MAXIMUM STRESS, ksi
120
100
80
60
40
20
0
CYCLES
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9
Fig. 102

Fig. 102



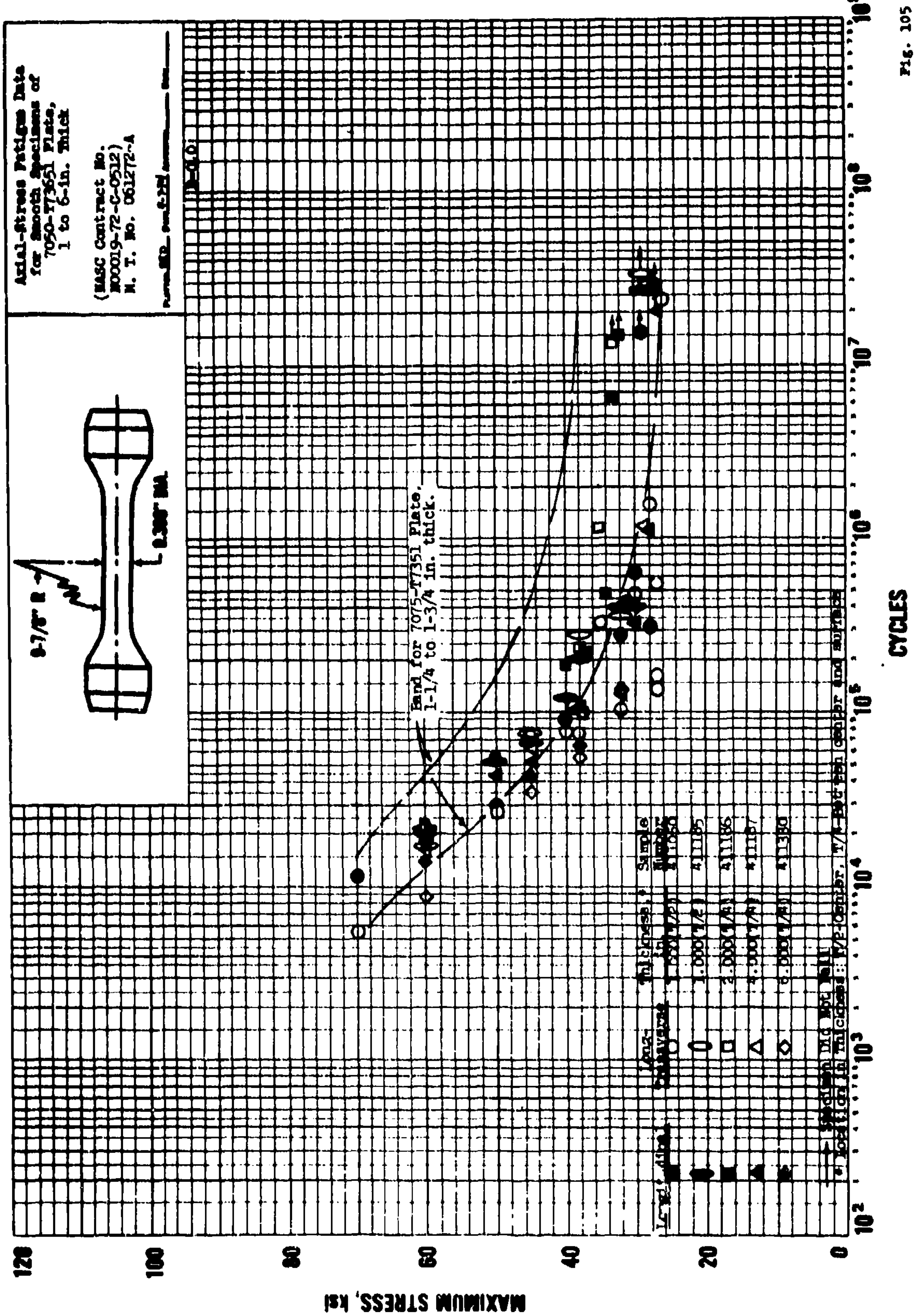
Axial-Stress Fatigue Data for Smooth Specimens of 7050-T73651 Plate, 1 to 6-in. Thick
(NASC Contract No. N00019-72-C-0512) M. T. No. 061272-A
MAXIMUM STRESS, ksi
CYCLES
Avg curve for 1.0 in. smooth specimens of 1-in. 7050-T73651 Plate (Fig. 102)

Fig. 103



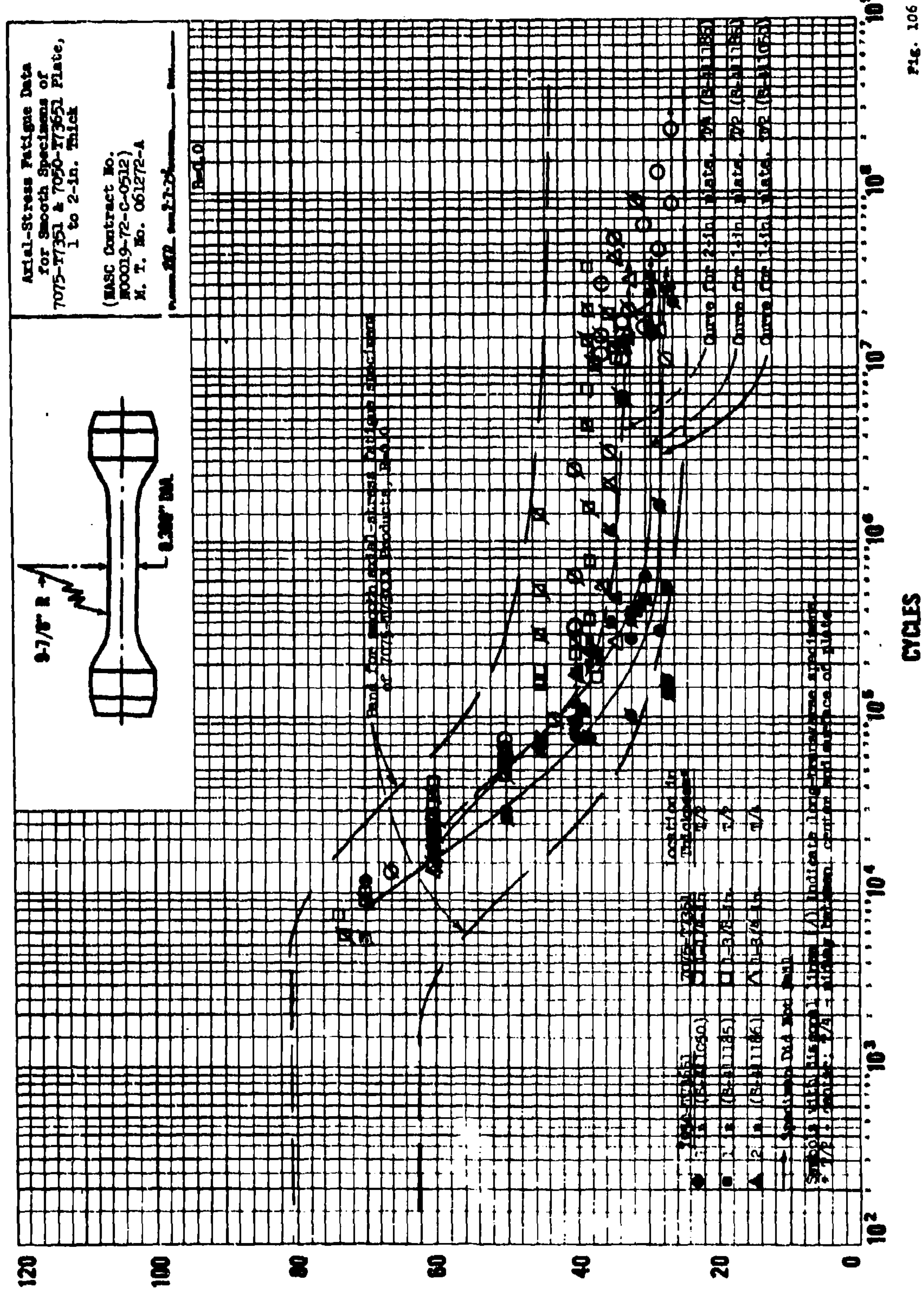
Axial-Stress Fatigue Data for Smooth Specimens of 7050-T73651 Plate, 1 to 6-in. Thick
(NASC Contract No. N00019-72-C-0512)
M. T. No. 061272-A
9-7/8" R
0.300" DIA.
L-S curve for L and LT smooth specimens of 1-in. 7050-T73651 plate (Fig. 102)
Long-Transverse
Thickness, in. (Sample No.)
Location in Thickness*
1.000 T/2
2.000 T/4
4.000 T/4
6.000 T/4
* T-Thickness of Plate
Specimen Did Not Fail
MAXIMUM STRESS, ksi
CYCLES
Fig. 104

Fig. 104



Axial-Stress Fatigue Data
for Smooth Specimens of
7050-T73651 Plate,
1 to 6-in. Thick
(NASC Contract No.
N00019-72-C-0512)
M. T. No. 061272-A
9-7/8" R
0.300" DIA.
Band for 7075-T7351 Plate,
1-1/4 to 1-3/4 in. thick.
MAXIMUM STRESS, ksi
CYCLES
Long-Transverse
Thickness,* in.
Sample Number
1.000(T/2)
411185
2.000(T/4)
411186
411187
6.000(T/4)
411380
Specimen Did Not Fail
* Location in Thickness: T/2-Center, T/4-Between center and surface
Fig. 105

Fig. 105



Axial-Stress Fatigue Data
for Smooth Specimens of
7075-T7351 & 7050-T73651 Plate,
1 to 2-in. Thick
(NASC Contract No.
N00019-72-C-0512)
M. T. No. 061272-A
R=0.0
MAXIMUM STRESS, ksi
CYCLES
0
20
40
60
80
100
120
Fig. 106

Fig. 106

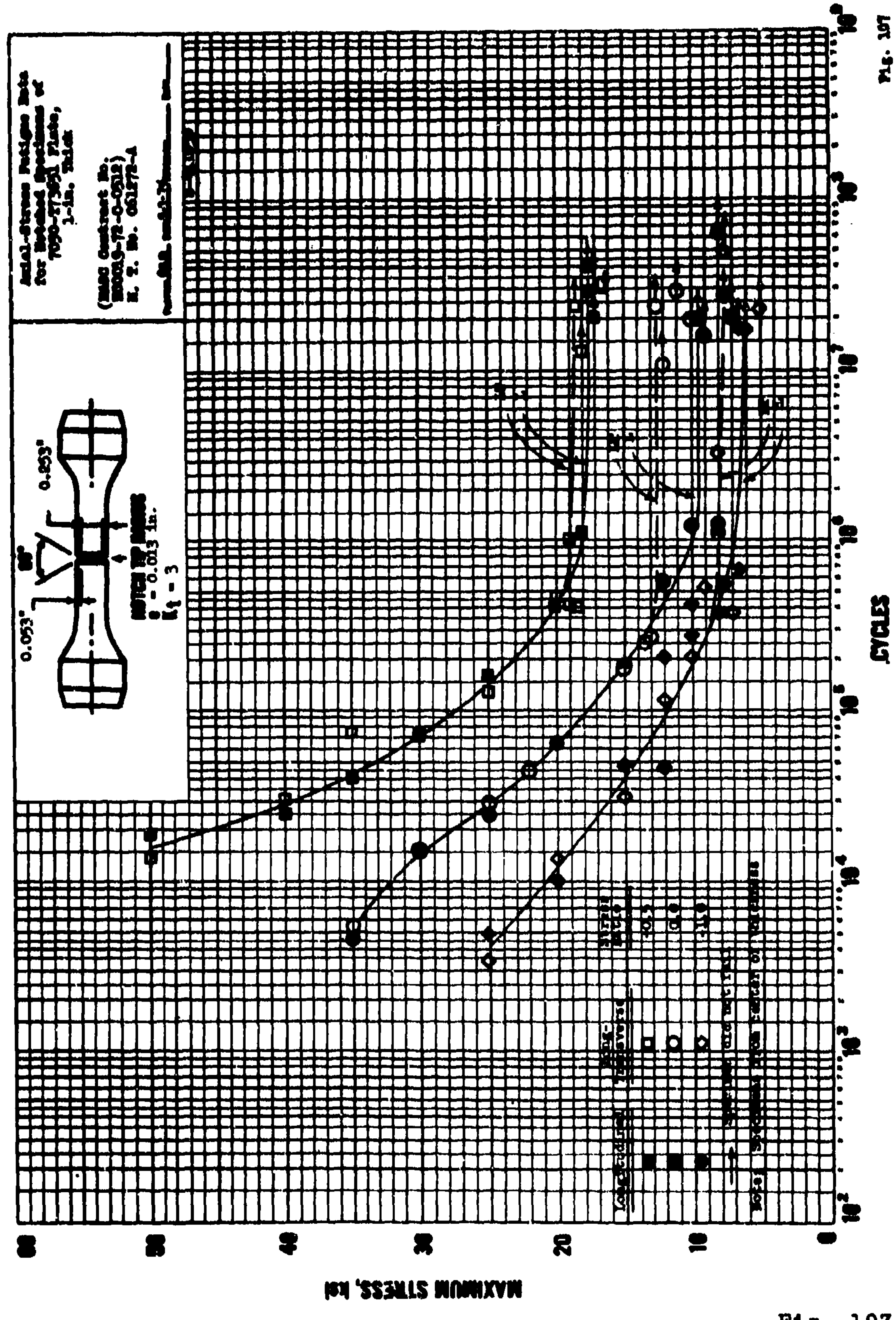


Fig. 107

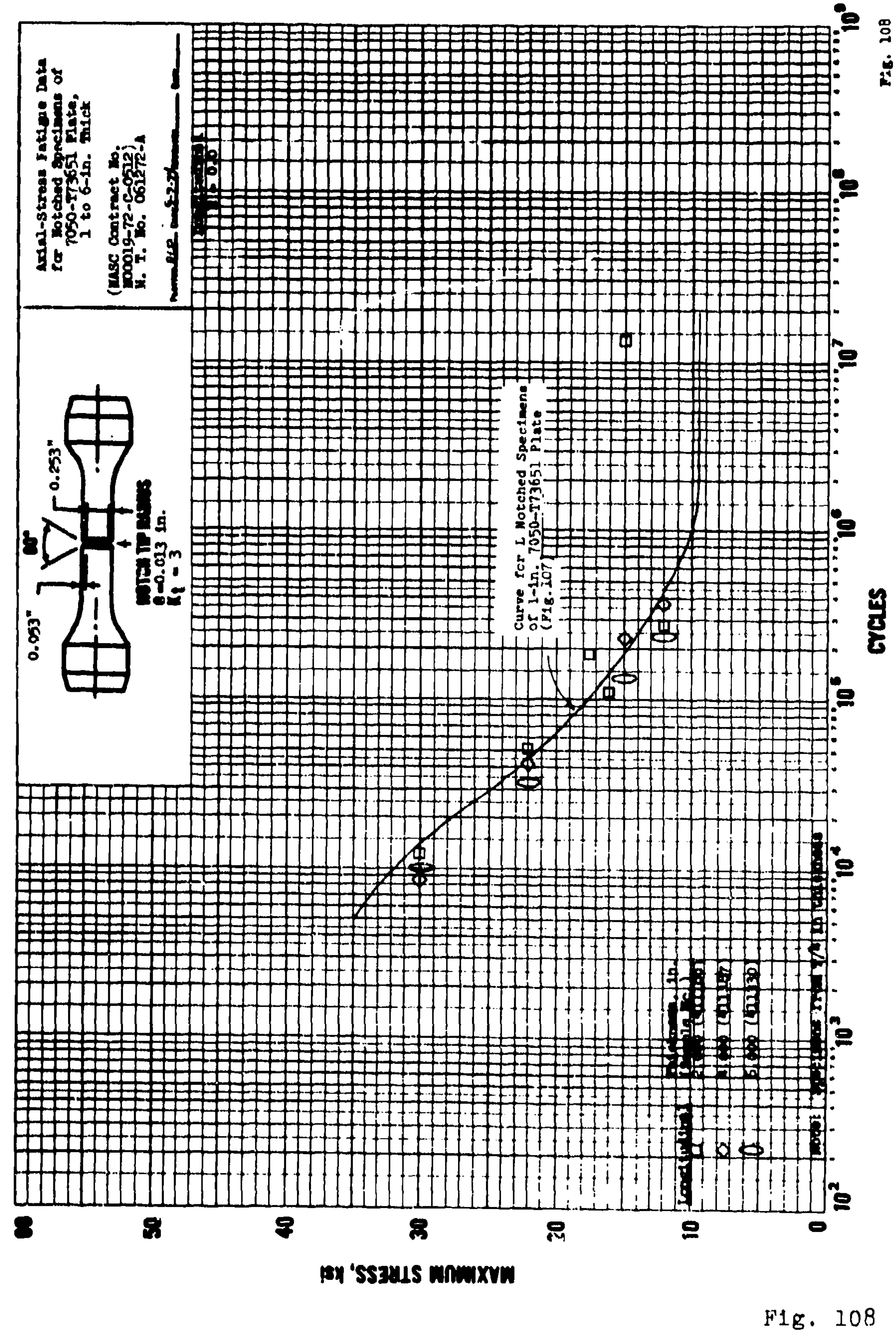

Axial-Stress Fatigue Data
for Notched Specimens of
7050-T73651 Plate,
1 to 6-in. Thick
(NASC Contract No.
N00019-72-C-0512)
N. T. No. 061272-A
0.053"
60°
0.253"
NOTCH TIP RADIUS
R=0.013 in.
Kt = 3
Curve for L Notched Specimens
of 1-in. 7050-T73651 Plate
(Fig.107)
Longitudinal
CYCLES
MAXIMUM STRESS, ksi
60
50
40
30
20
10
0
Fig. 108

Fig. 108

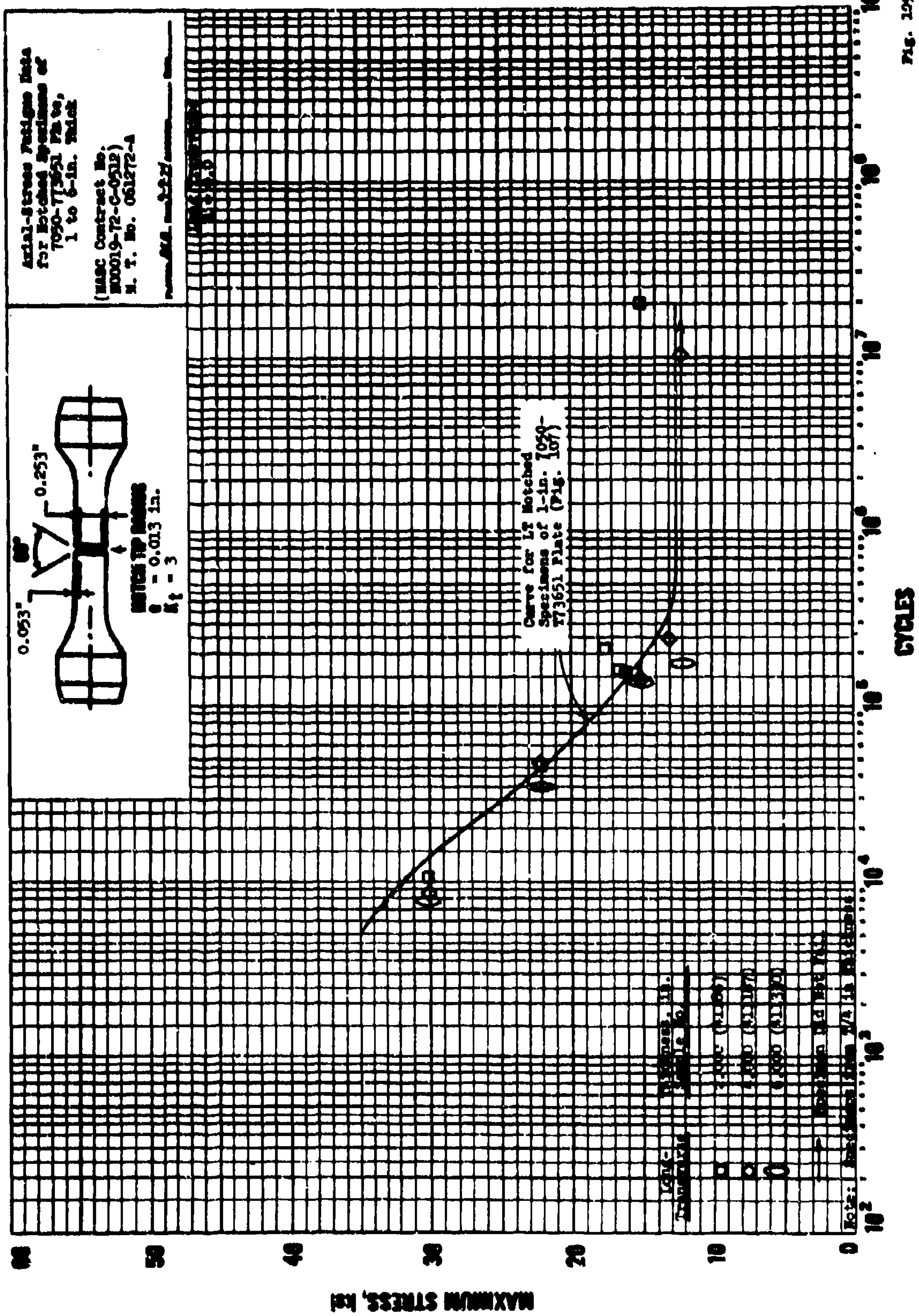
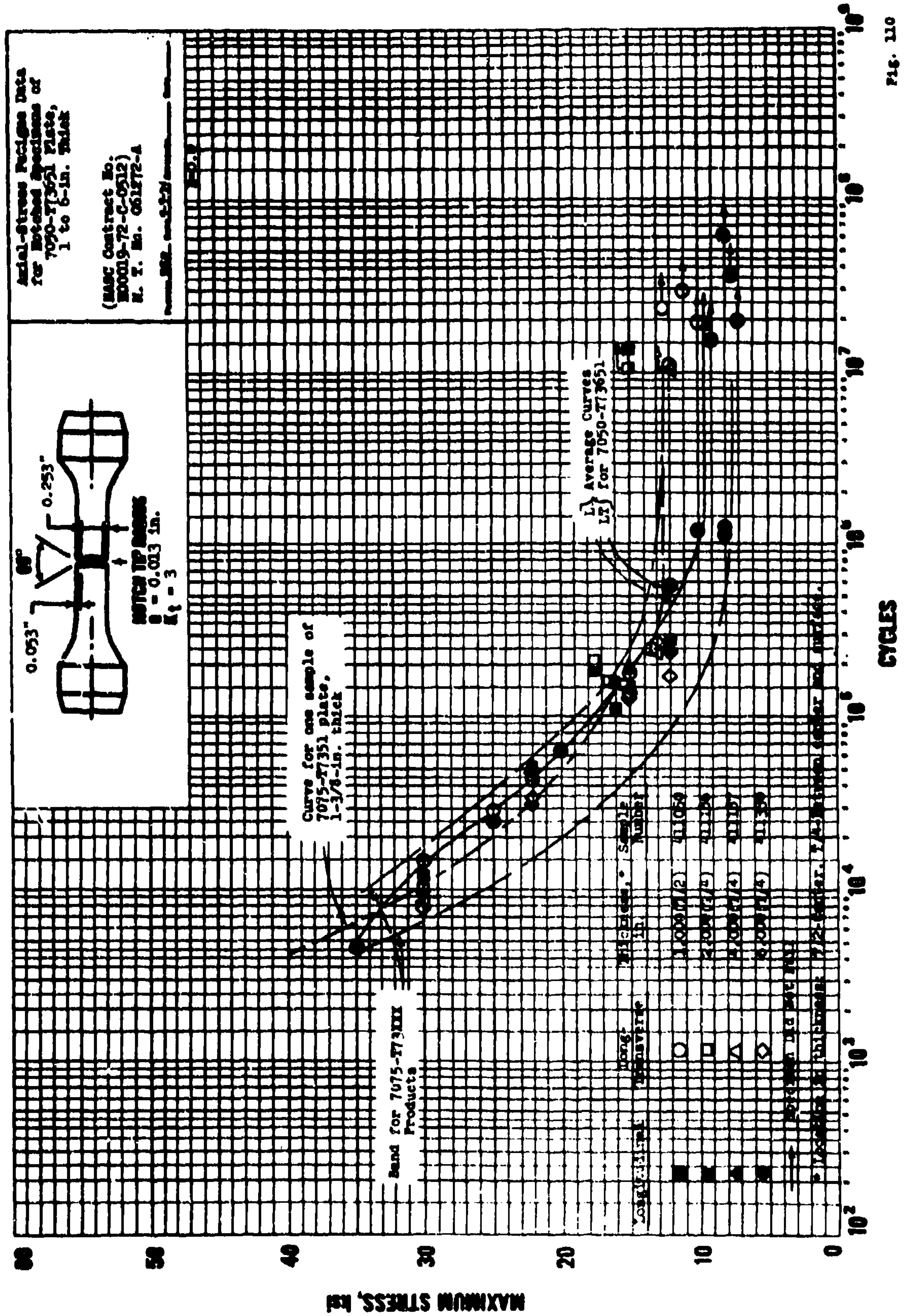


Fig. 109



Axial-Stress Fatigue Data for Notched Specimens of 7050-T7351 Plate, 1 to 6-in. Thick
(NASC Contract No. N00019-72-C-0512)
0.053"
60°
0.253"
NOTCH TIP RADIUS
R = 0.013 in.
K_t = 3
Curve for one sample of 7075-T7351 plate, 1-3/8-in. thick
Band for 7075-T73XX Products
LT Average Curves for 7050-T7351
MAXIMUM STRESS, ksi
CYCLES
Fig. 110

Fig. 110

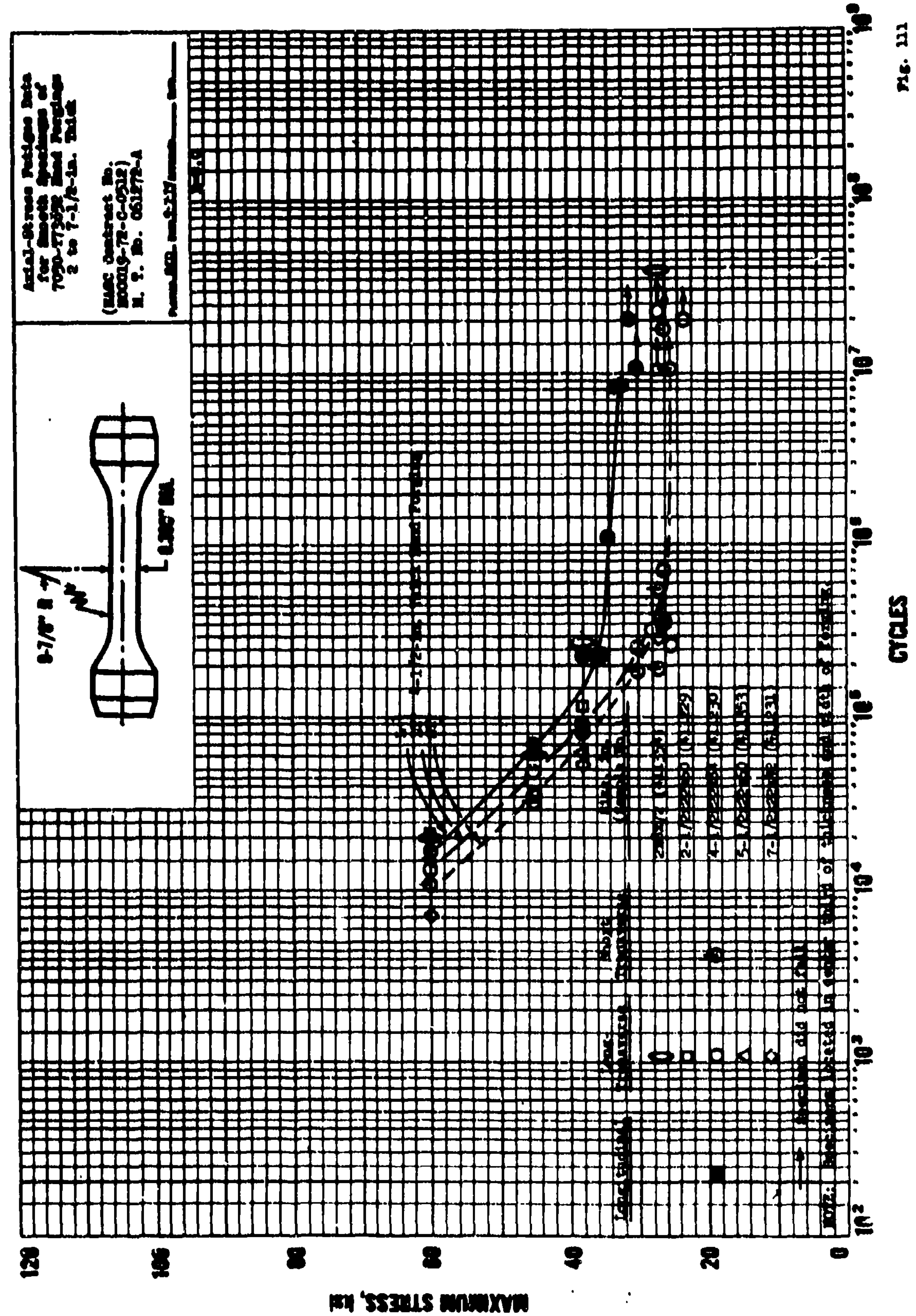


Fig. 111

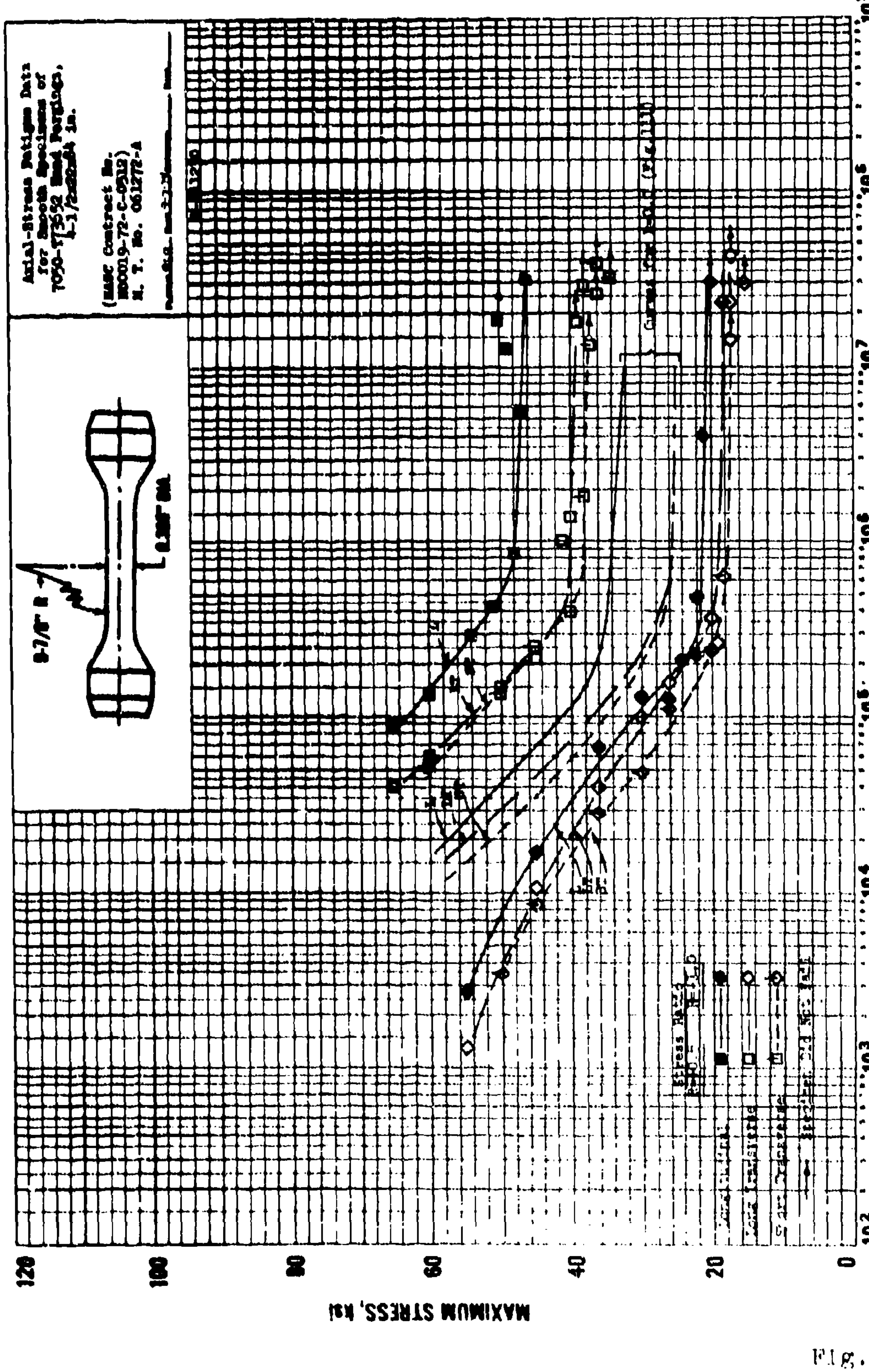


Fig. 112

Fig. 112

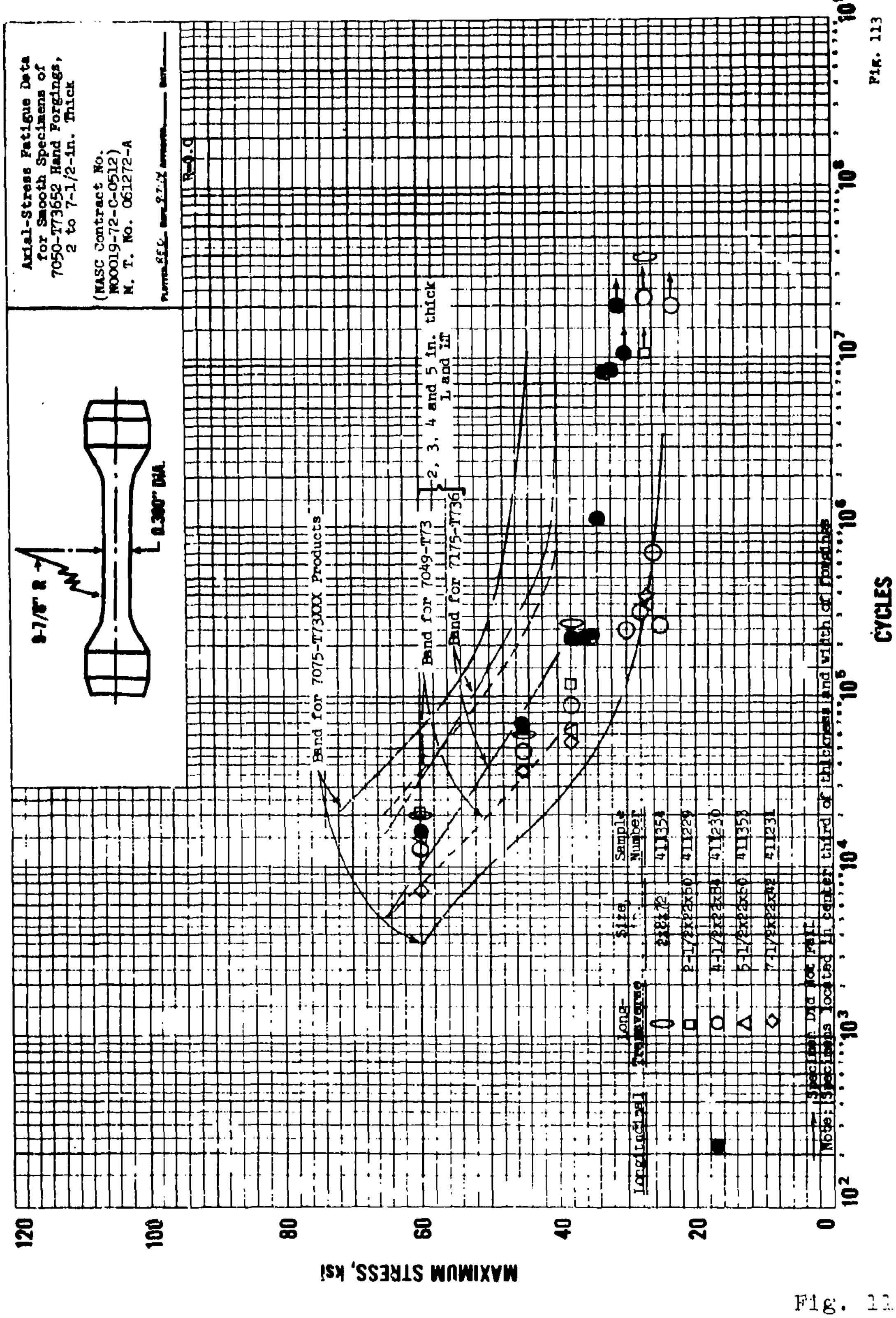

Axial-Stress Fatigue Data for Smooth Specimens of 7050-T73652 Hand Forgings, 2 to 7-1/2-in. Thick
(NASC Contract No. N00019-72-C-0512)
M. T. No. 061272-A
R=0.0
9-7/8" R
0.300" DIA.
Band for 7075-T73XXX Products
Band for 7049-T73
Band for 7175-T736
2, 3, 4 and 5 in. thick L and LT
Longitudinal
Long-Transverse
Size
Sample Number
2-1/2x2x50
411229
411354
411230
411353
411231
Specimen Did Not Fail
Note: Specimens located in center third of thickness and width of forgings
MAXIMUM STRESS, ksi
120
100
80
60
40
20
0
CYCLES
Fig. 113

Fig. 113

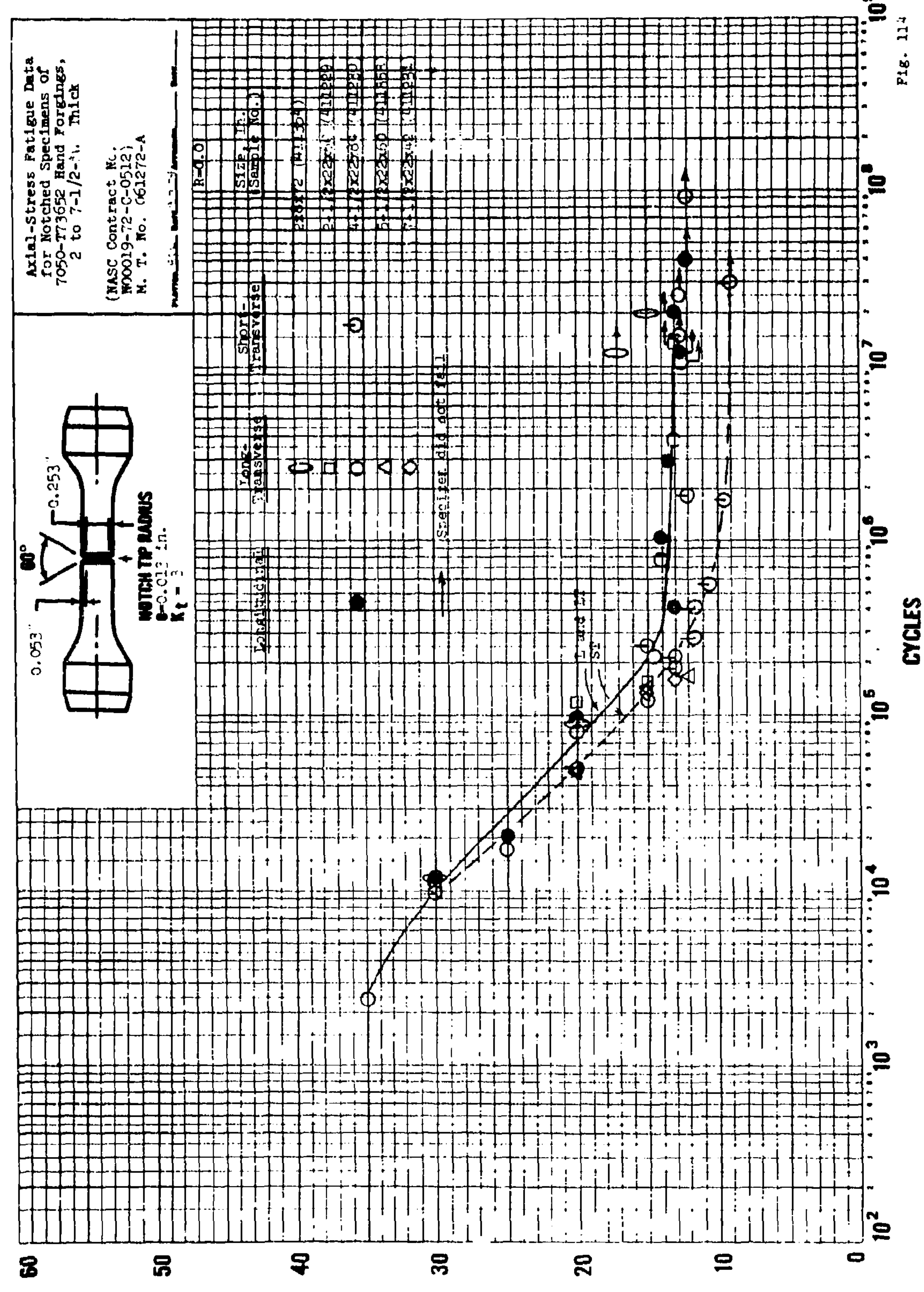

Axial-Stress Fatigue Data
for Notched Specimens of
7050-T73652 Hand Forgings,
2 to 7-1/2-in. Thick
(NASC Contract No.
N00019-72-C-0512)
M. T. No. 061272-A
0.053"
60°
0.253"
NOTCH TIP RADIUS
Kt = 3
R=0.0
Longitudinal
Long-Transverse
Short-Transverse
Size, In.
(Sample No.)
Specimen did not fail
L and LT
ST
MAXIMUM STRESS, ksi
CYCLES
Fig. 114

Fig. 114

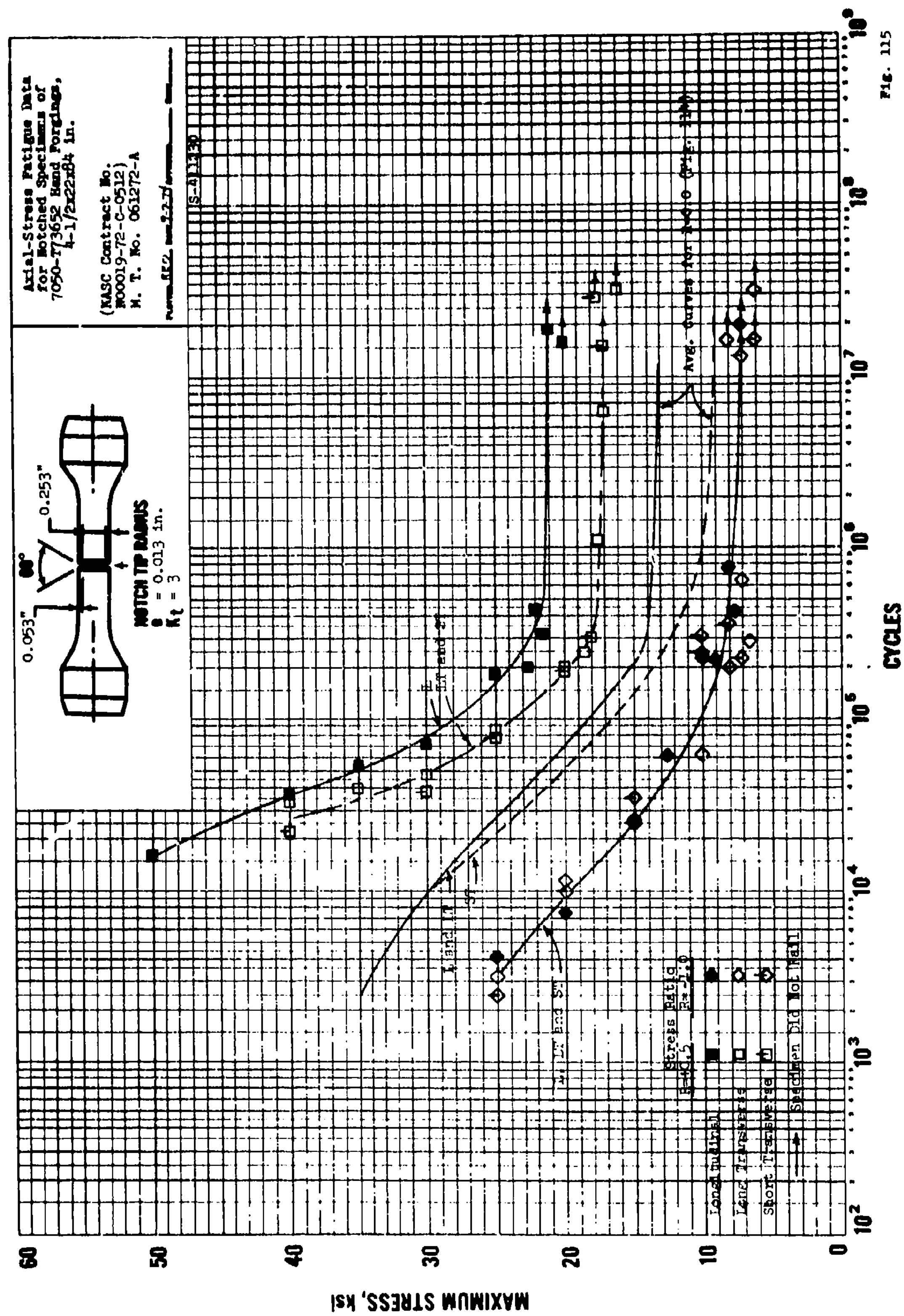

Axial-Stress Fatigue Data for Notched Specimens of 7050-T73652 Hand Forgings, 4-1/2x22x84 in.
(NASC Contract No. N00019-72-C-0512)
M. T. No. 061272-A
S-411330
NOTCH TIP RADIUS
Kt = 3
0.053"
0.253"
Longitudinal
Long Transverse
Short Transverse
Specimen Did Not Fail
Stress Ratio
MAXIMUM STRESS, ksi
CYCLES
Fig. 115

Fig. 115

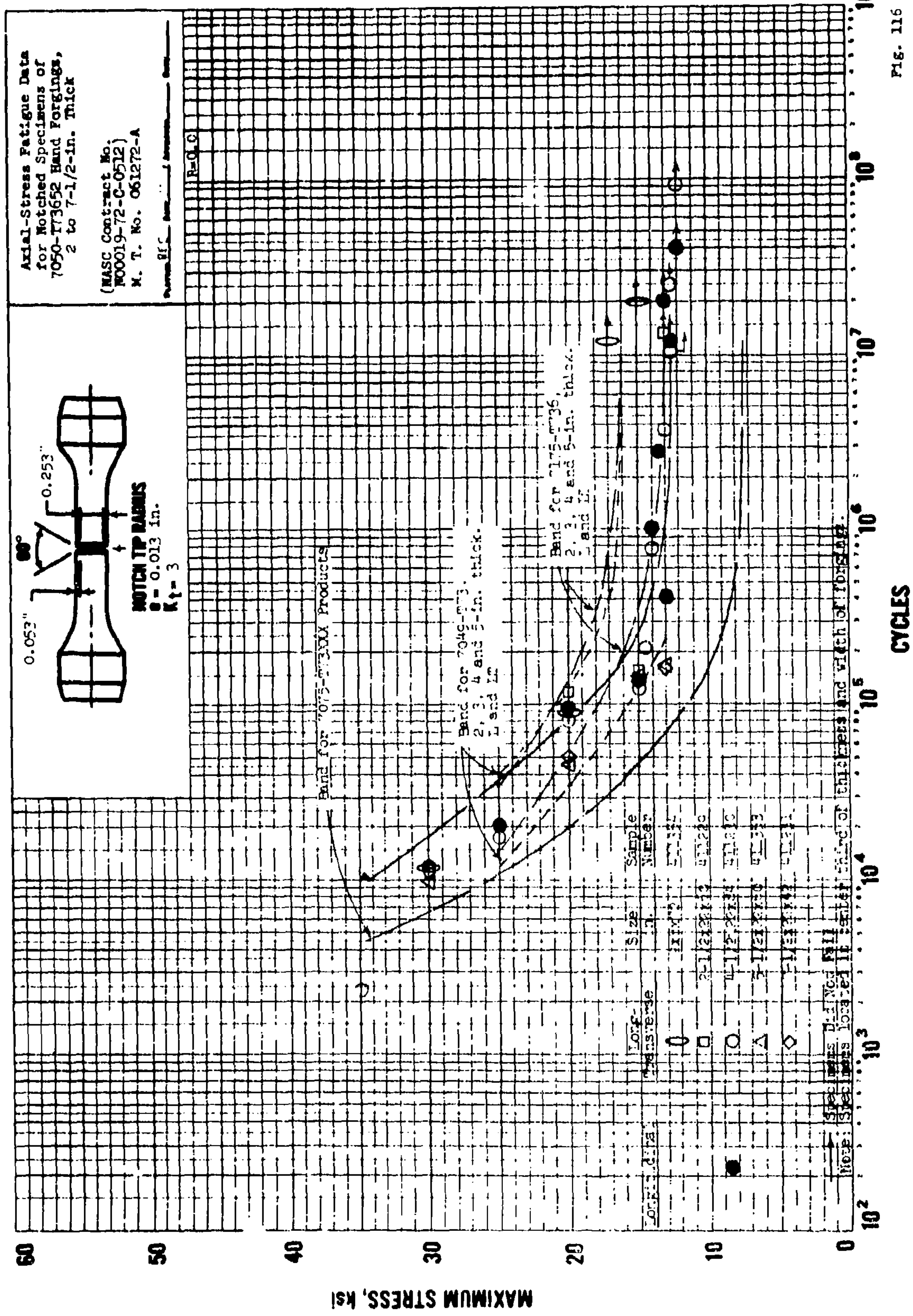

Axial-Stress Fatigue Data for Notched Specimens of 7050-T73652 Hand Forgings, 2 to 7-1/2-in. Thick
(NASC Contract No. N00019-72-C-0512)
W. T. No. 061272-A
R=0.0
NOTCH TIP RADIUS
R = 0.013 in.
Kt = 3
0.053"
0.253"
60°
Band for 7075-T73XX Products
Band for 7049-T73, 2, 3, 4 and 5-in. thick, L and LT
Band for 7175-T736, 2, 3, 4 and 5-in. thick, L and LT
MAXIMUM STRESS, ksi
CYCLES
Fig. 116

Fig. 116

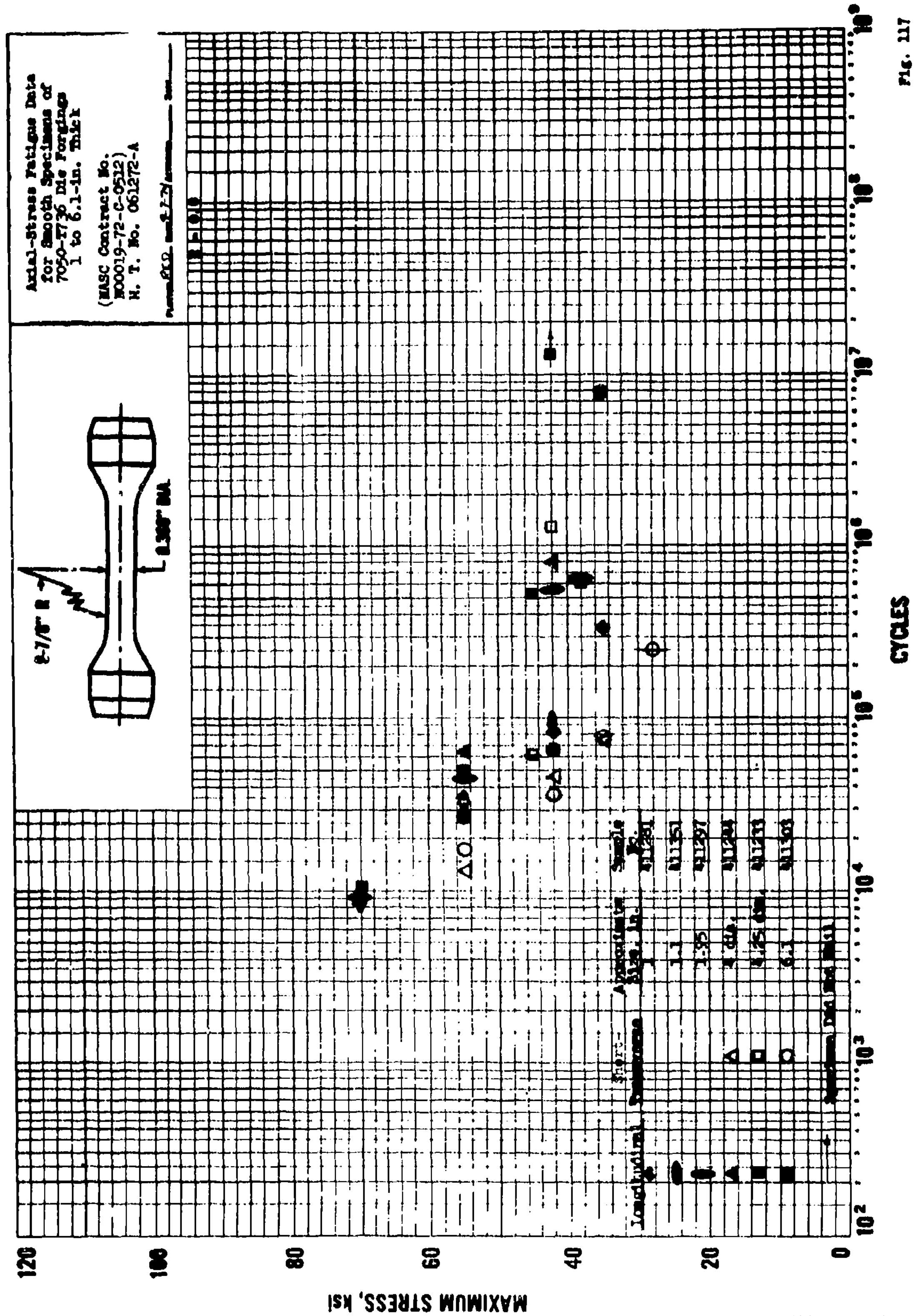

Axial-Stress Fatigue Data for Smooth Specimens of 7050-T736 Die Forgings 1 to 6.1-in. Thick
(NASC Contract No. N00019-72-C-0512)
N. T. No. 061272-A
8-7/8" R
0.300" DIA.
Longitudinal
Short-Transverse
Approximate Size, in.
Sample No.
1.1
1.95
4 dia.
4.25 dia.
6.1
MAXIMUM STRESS, ksi
CYCLES

Fig. 117

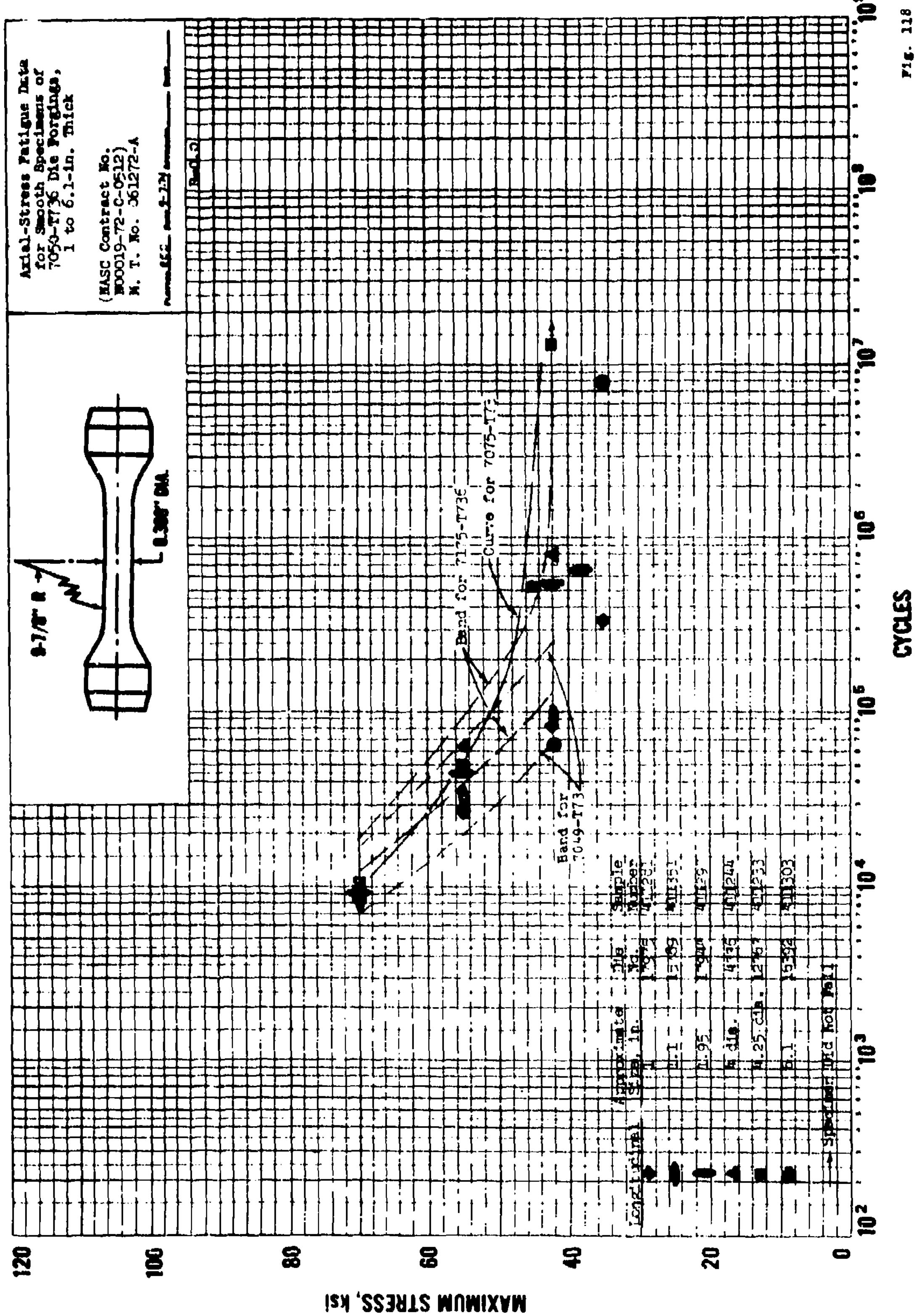

Axial-Stress Fatigue Data
for Smooth Specimens of
7050-T736 Die Forgings,
1 to 6.1-in. Thick
(NASC Contract No.
N00019-72-C-0512)
M. T. No. 361272-A
9-7/8" R
0.300" DIA.
Band for 7175-T736
Curve for 7075-T73
Band for
7049-T73
Longitudinal
Approximate Size, in.
Die No.
Sample Number
Specimen Did Not Fail
MAXIMUM STRESS, ksi
CYCLES
Fig. 118

Fig. 118

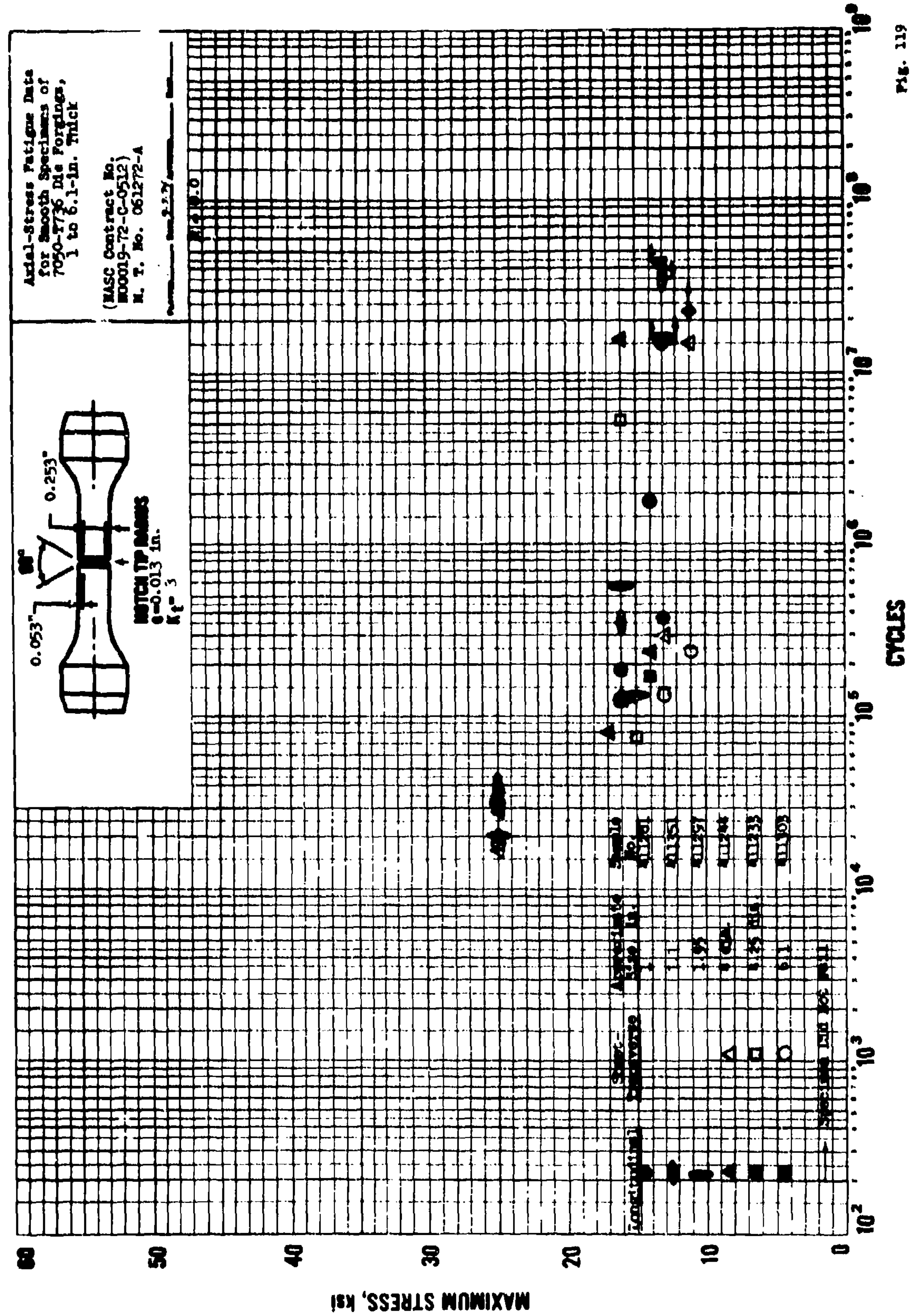

Axial-Stress Fatigue Data for Smooth Specimens of 7050-T736 Die Forgings, 1 to 6.1-in. Thick
MAXIMUM STRESS, ksi
CYCLES
Fig. 119

Fig. 119

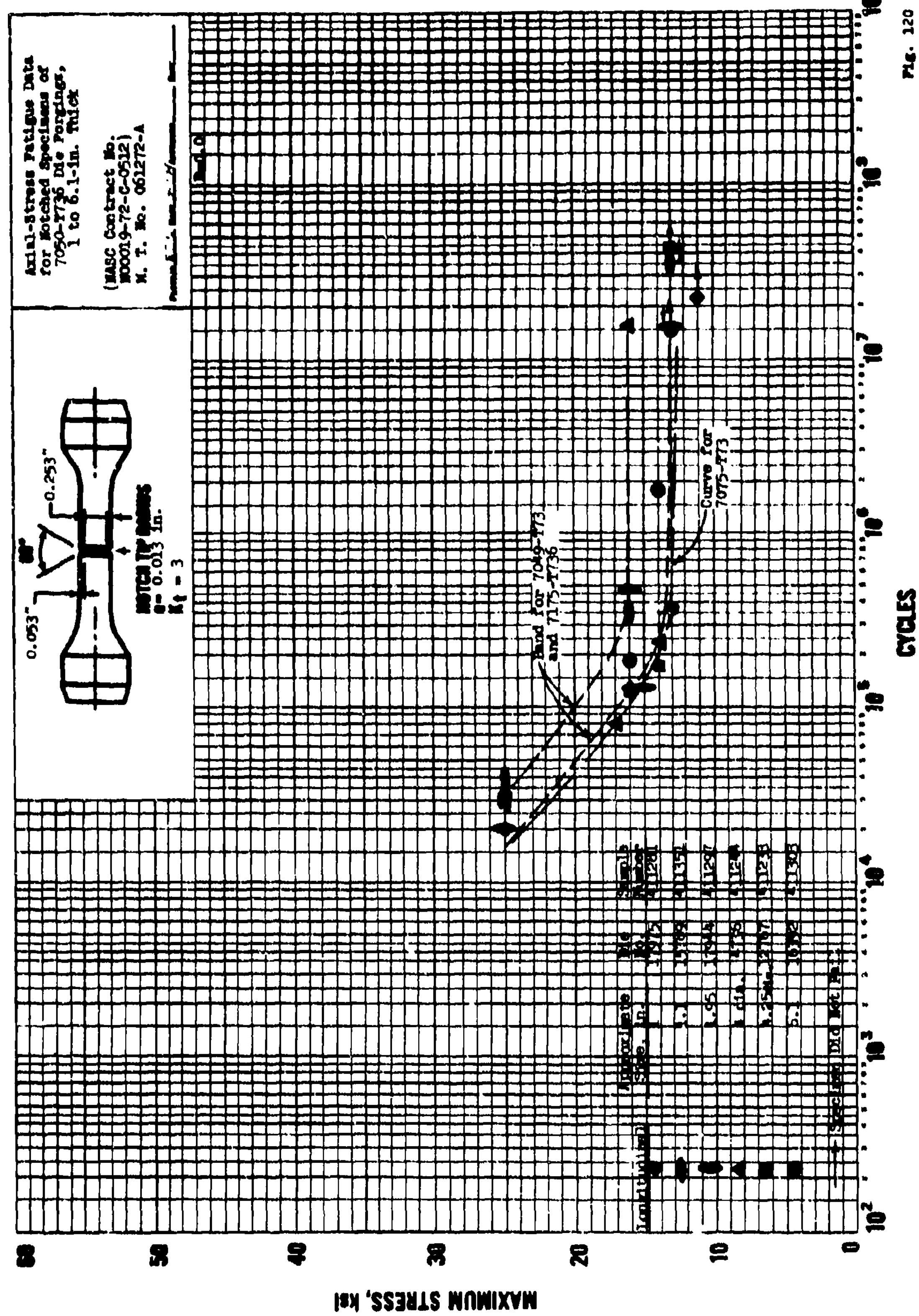

Axial-Stress Fatigue Data for Notched Specimens of 7050-T736 Die Forgings, 1 to 6.1-in. Thick
(NASC Contract No. N00019-72-C-0512)
M. T. No. 061272-A
0.053"
0.253"
60°
NOTCH TIP RADIUS
ρ= 0.013 in.
K_t = 3
Band for 7049-T73 and 7175-T736
Curve for 7075-T73
Approximate Size, in.
Die No.
Sample Number
Specimen Did Not Fail
MAXIMUM STRESS, ksi
CYCLES
0
10
20
30
40
50
60
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9
Fig. 120

Fig. 120

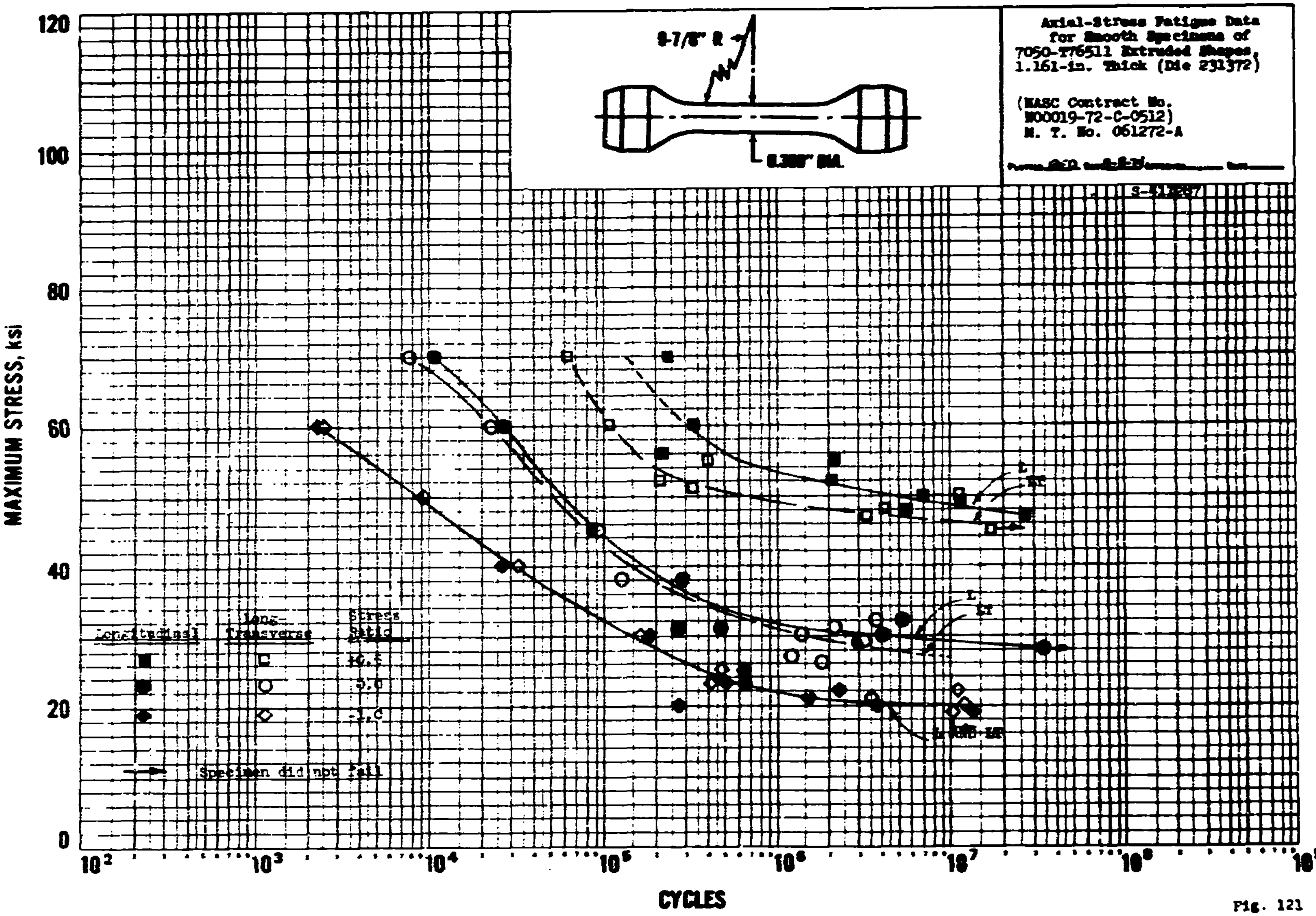


Fig. 121

Fig. 121

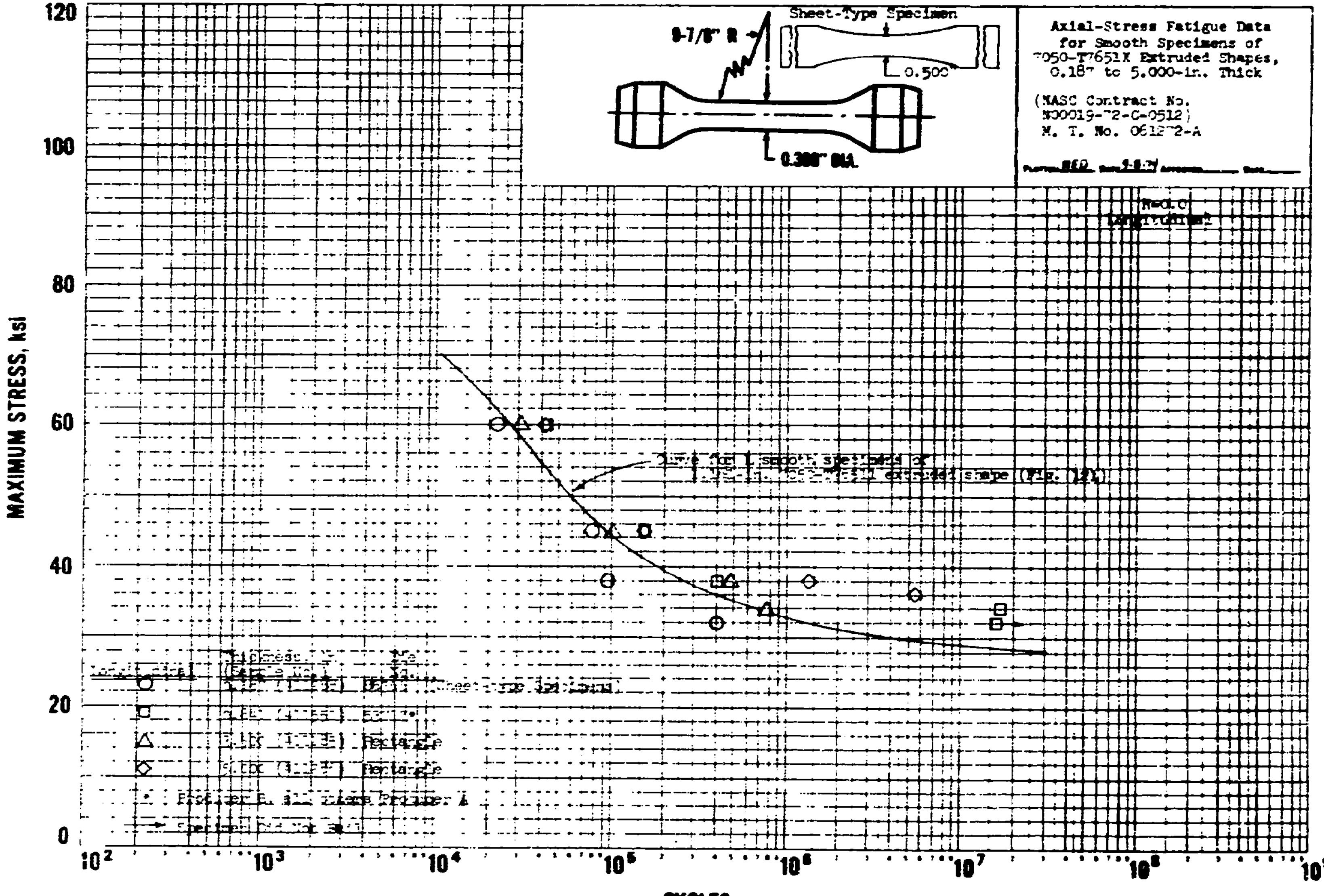


Fig. 122

Fig. 122

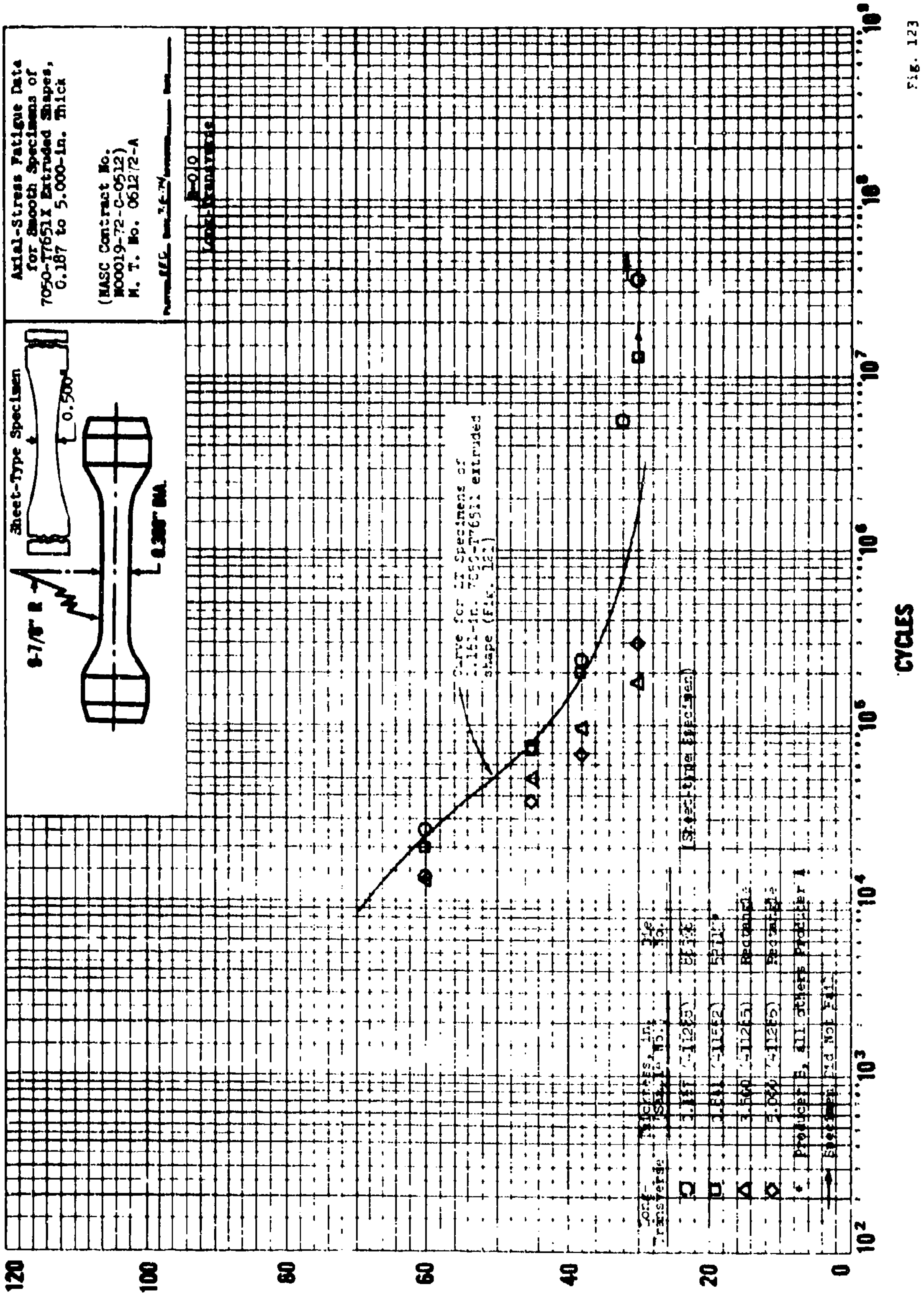

Axial-Stress Fatigue Data
for Smooth Specimens of
7050-T7651X Extruded Shapes,
0.187 to 5.000-in. Thick
(NASC Contract No.
N00019-72-C-0512)
M. T. No. 061272-A
Sheet-Type Specimen
0.500"
MAXIMUM STRESS, ksi
120
100
80
60
40
20
0
CYCLES
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9
Fig. 123

Fig. 123

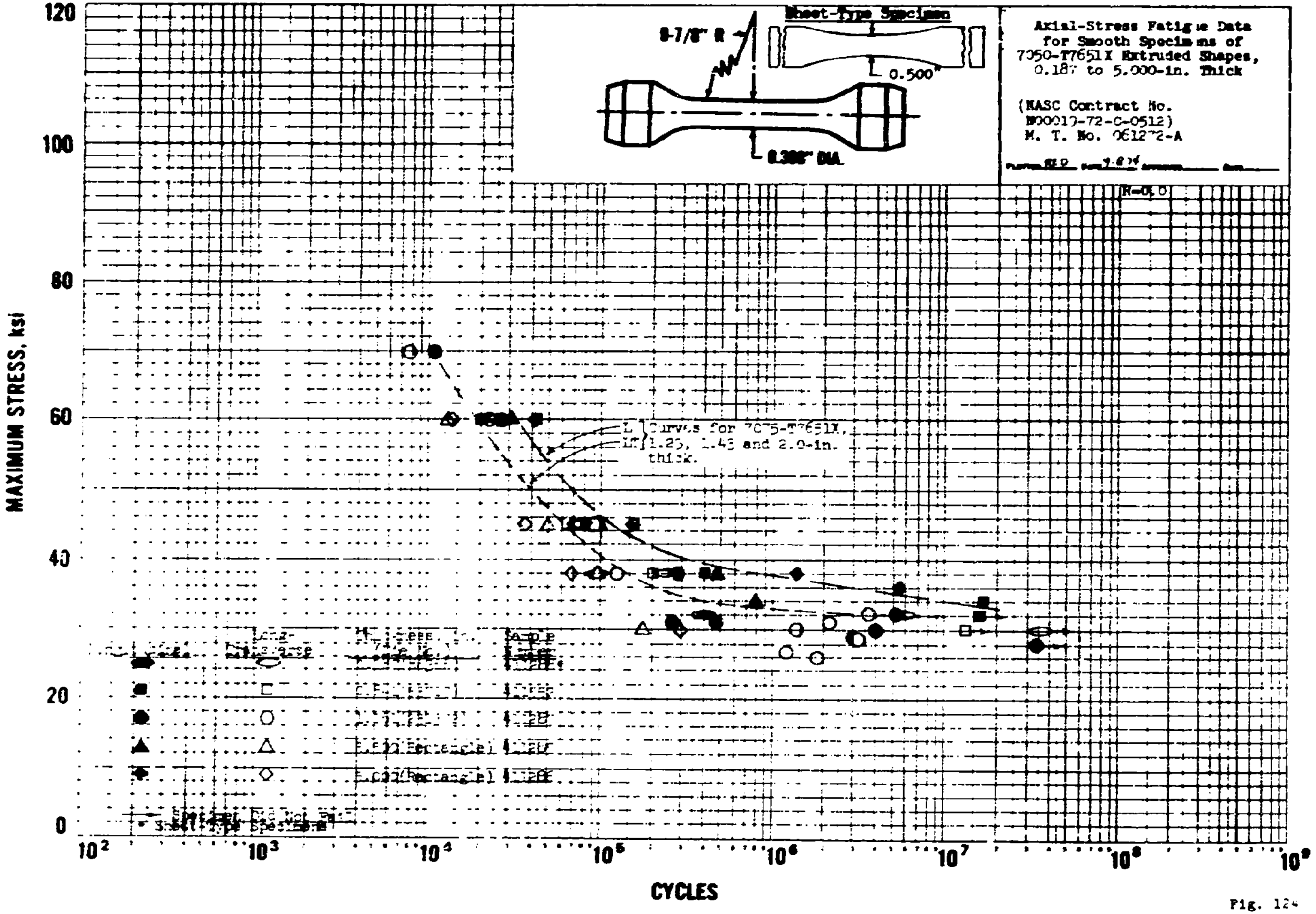

Axial-Stress Fatigue Data for Smooth Specimens of 7050-T7651X Extruded Shapes, 0.187 to 5.000-in. Thick
(NASC Contract No. N00019-72-C-0512)
M. T. No. 061272-A
Sheet-Type Specimen
9-7/8" R
0.500"
0.300" DIA.
R=0.0
Curves for 7075-T7651X, 1.25, 1.43 and 2.0-in. thick
MAXIMUM STRESS, ksi
CYCLES
120
100
80
60
40
20
0
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9

Fig. 124

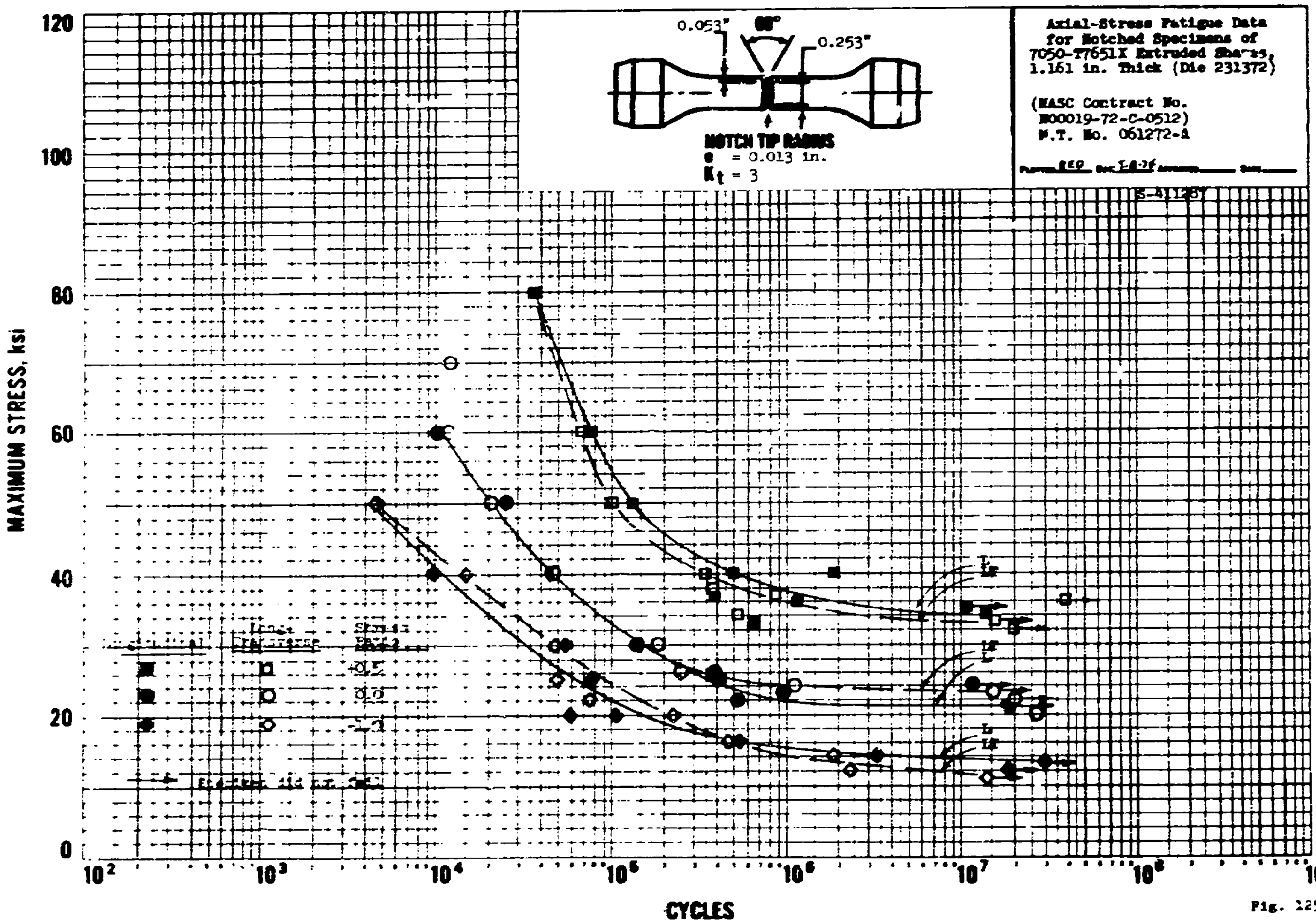

Axial-Stress Fatigue Data
for Notched Specimens of
7050-T7651X Extruded Shapes,
1.161 in. Thick (Die 231372)
(NASC Contract No.
N00019-72-C-0512)
W.T. No. 061272-A
S-41128
0.053"
60°
0.253"
NOTCH TIP RADIUS
= 0.013 in.
K_t = 3
MAXIMUM STRESS, ksi
CYCLES
L
LT
+0.5
0.0
-1.0

Fig. 125

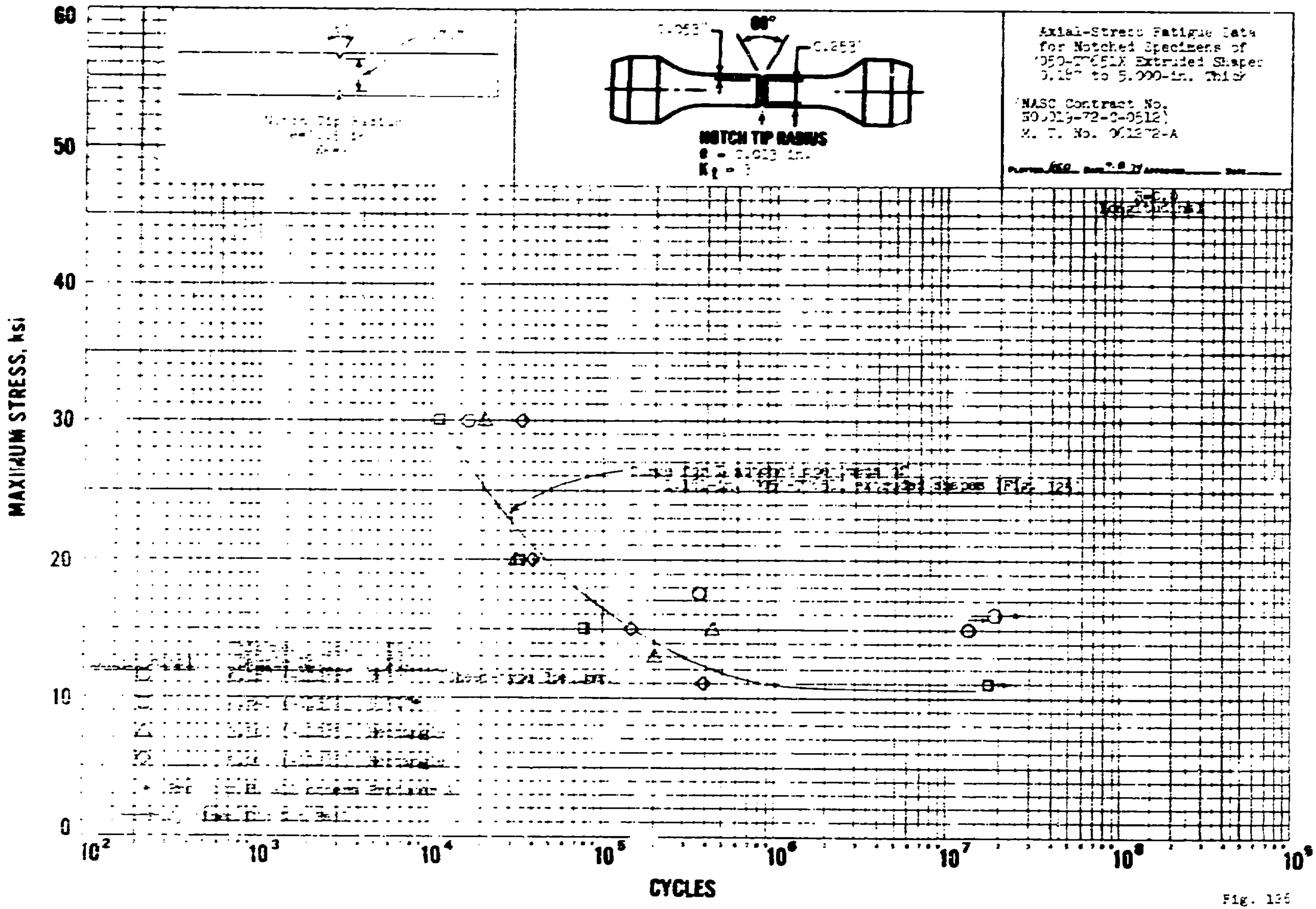

Axial-Stress Fatigue Data
for Notched Specimens of
Extruded Shapes
NASC Contract No.
NOTCH TIP RADIUS
60°
0.253"
MAXIMUM STRESS, ksi
CYCLES
60
50
40
30
20
10
0
10^2
10^3
10^4
10^5
10^6
10^7
10^8
10^9

Fig. 136

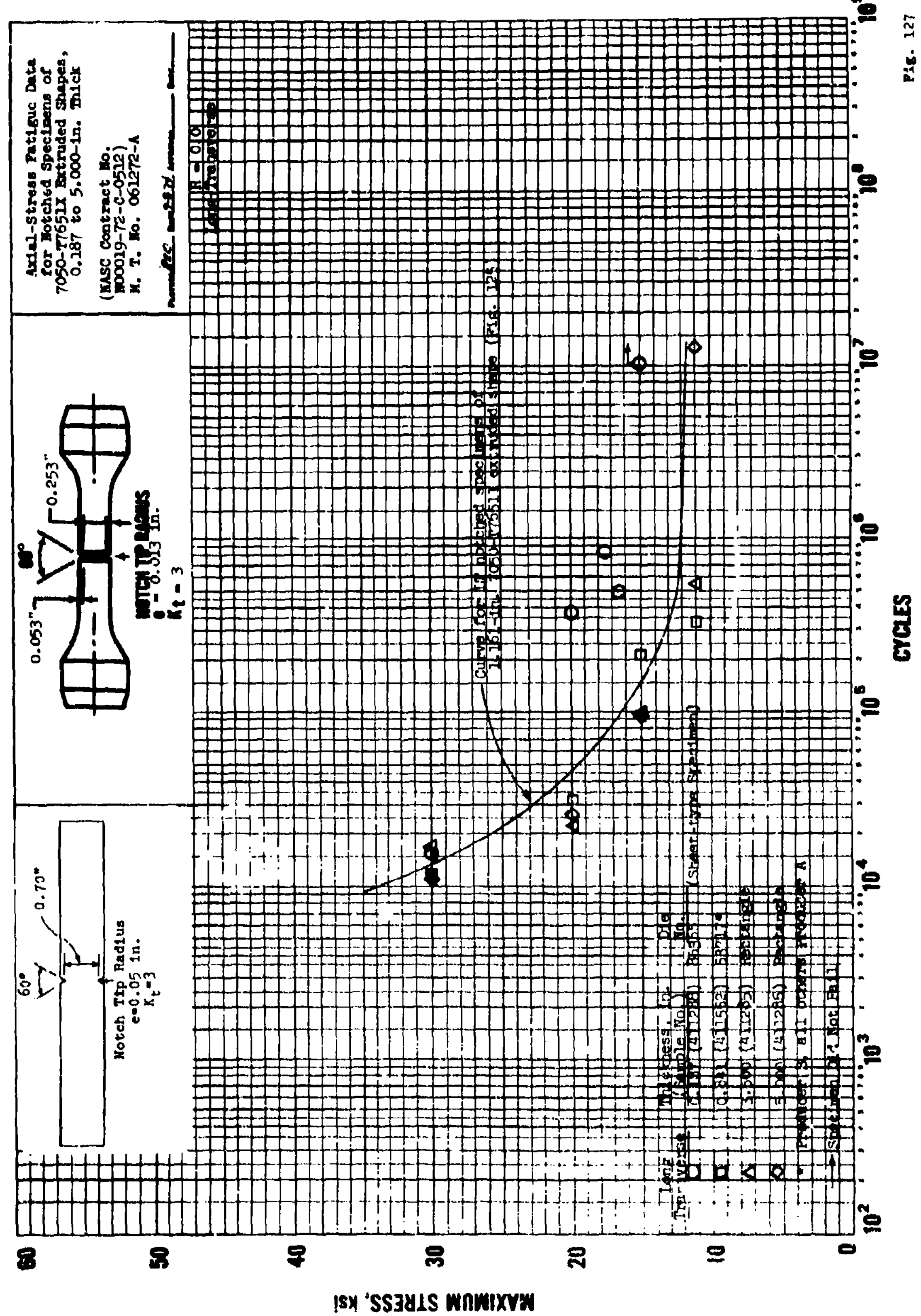
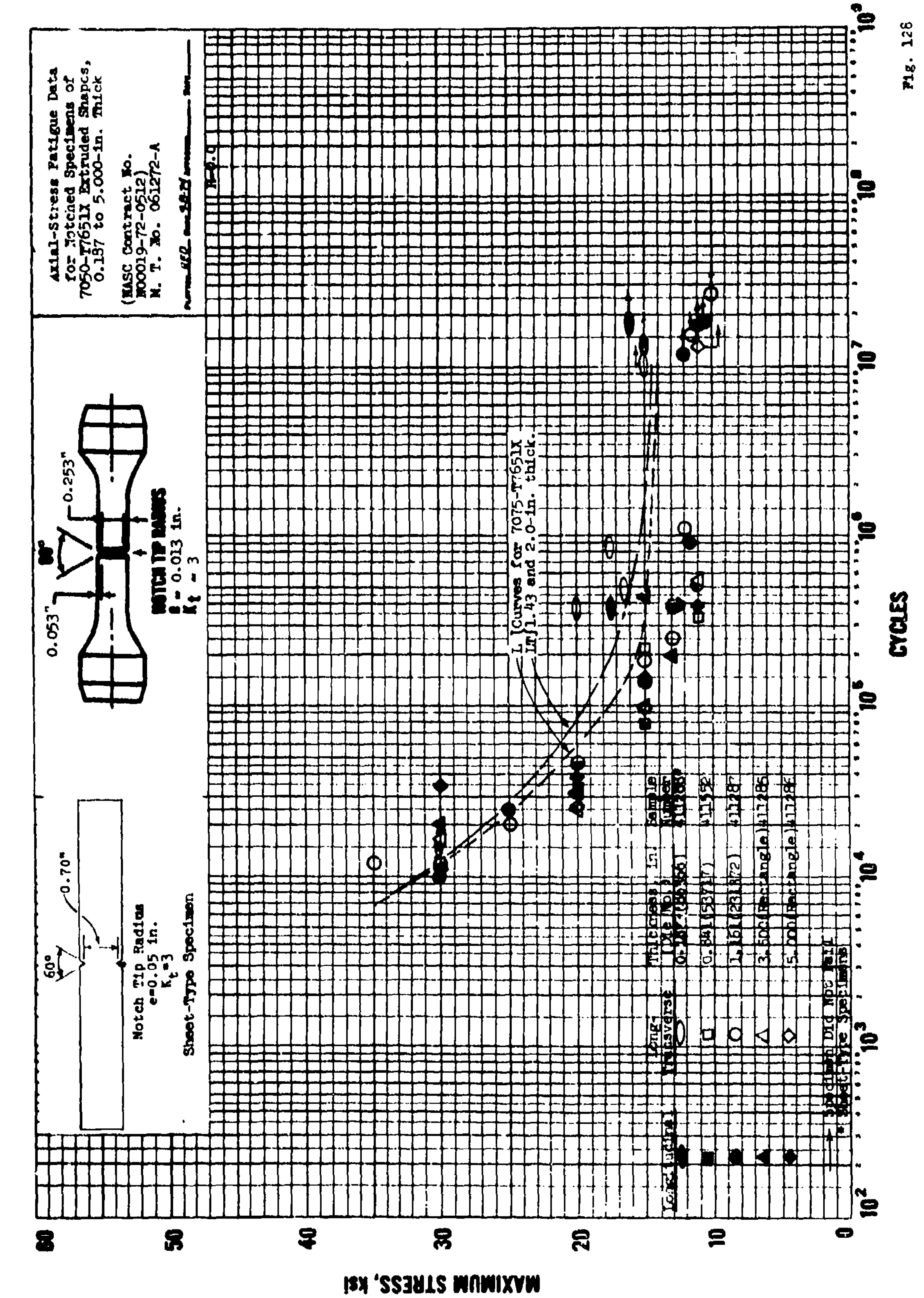

Axial-Stress Fatigue Data
for Notched Specimens of
7050-T7651X Extruded Shapes,
0.187 to 5.000-in. Thick
(NASC Contract No.
N00019-72-C-0512)
M. T. No. 061272-A
R = 0.0
Long-Transverse
60°
0.70"
Notch Tip Radius
e=0.05 in.
K_t=3
0.053"
60°
0.253"
NOTCH TIP RADIUS
e = 0.013 in.
K_t = 3
Curve for 17 notched specimens of
1.161-in. 7050-T7651X extruded shape (Fig. 126)
Long Transverse
Thickness, In. (Sample No.)
Die No.
0.187 (411280) B6365 (Sheet-type Specimen)
0.841 (411552) 587174
3.500 (411265) Rectangle
5.000 (411285) Rectangle
* Producer B, all others Producer A
→ Specimen Did Not Fail
MAXIMUM STRESS, ksi
CYCLES
Fig. 127

Fig. 127



Axial-Stress Fatigue Data
for Notched Specimens of
7050-T7651X Extruded Shapes,
0.137 to 5.000-in. Thick
(NASC Contract No.
N00019-72-0512)
M. T. No. 061272-A
Notch Tip Radius
ρ=0.05 in.
Kt=3
Sheet-Type Specimen
NOTCH TIP RADIUS
ρ = 0.013 in.
Kt = 3
Curves for 7075-T7651X
1.43 and 2.0-in. thick
CYCLES
MAXIMUM STRESS, ksi
Fig. 126

Fig. 128

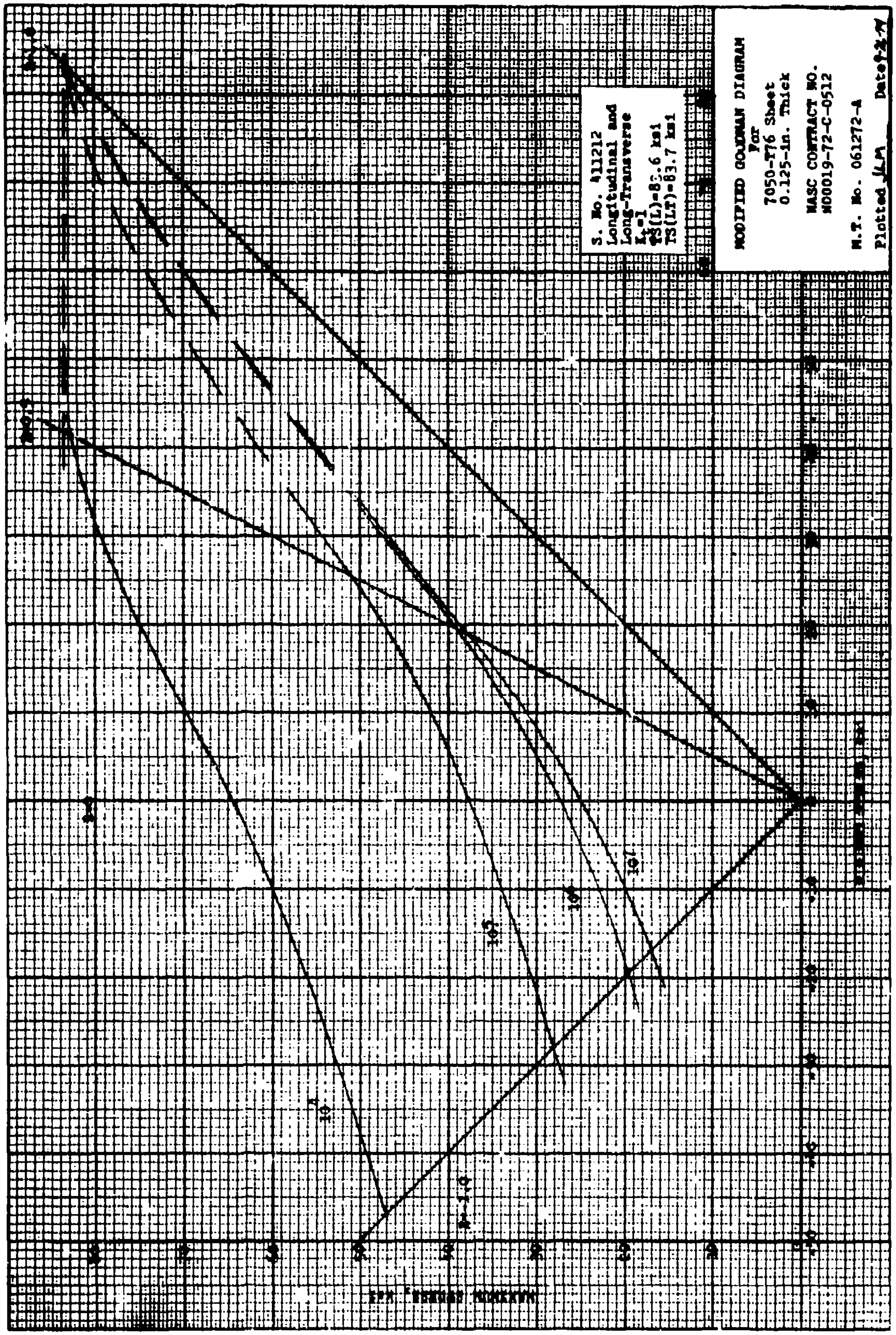

MODIFIED GOODMAN DIAGRAM
For
7050-T76 Sheet
0.125-in. Thick
NASC CONTRACT NO.
N00019-72-C-0512
M.T. No. 061272-A
S. No. 411212
Longitudinal and
Long-Transverse

Fig. 129

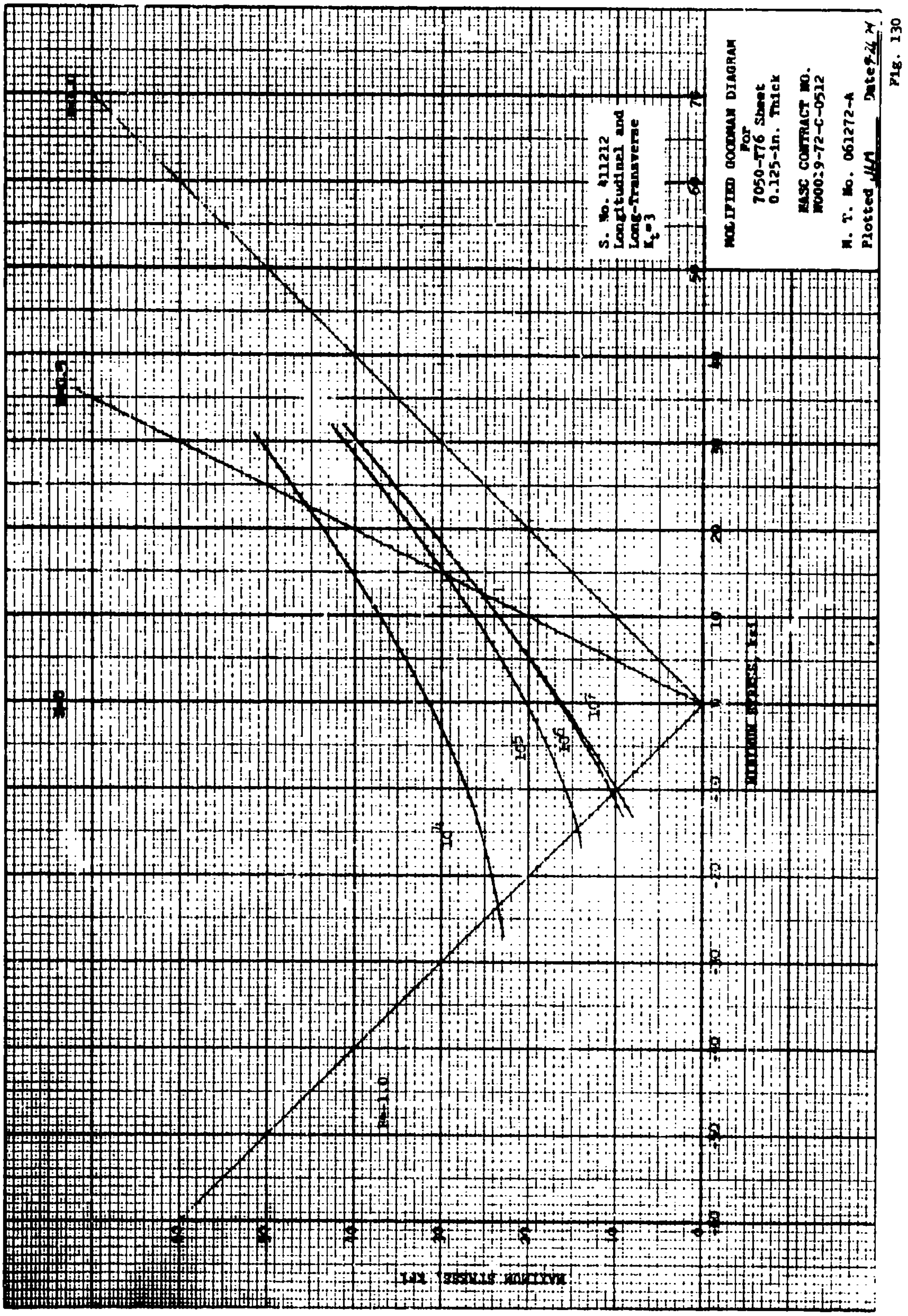

MODIFIED GOODMAN DIAGRAM
For
7050-T76 Sheet
0.125-in. Thick
NASC CONTRACT NO.
N00019-72-C-0512
N. T. No. 061272-A
S. No. 411212
Longitudinal and
Long-Transverse
R=-1.0
MINIMUM STRESS, ksi
MAXIMUM STRESS, ksi
Fig. 130

Fig. 130

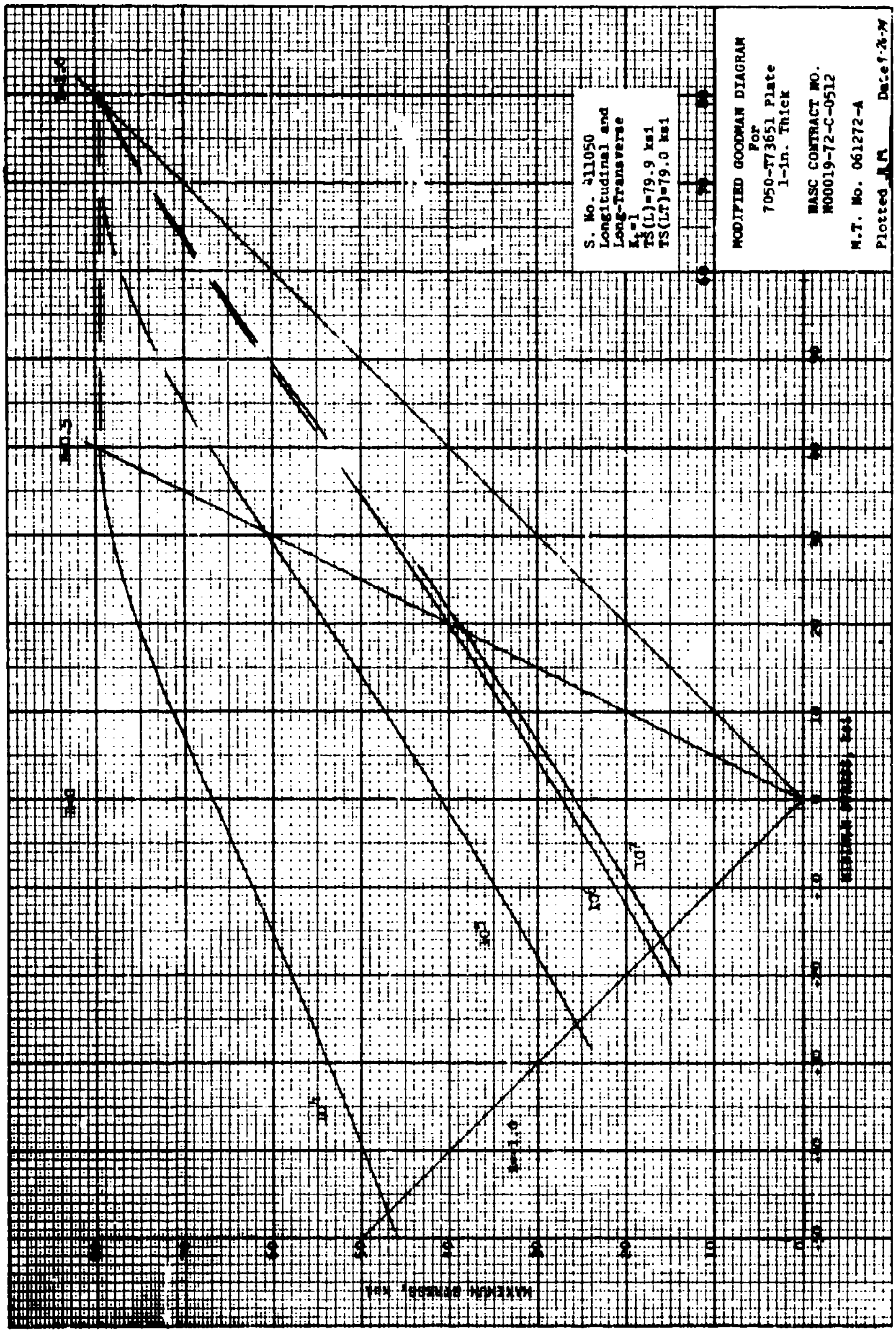

S. No. 311050
Longitudinal and
Long-Transverse
TS(L)=79.9 ksi
TS(LT)=79.0 ksi
MODIFIED GOODMAN DIAGRAM
For
7050-T73651 Plate
1-in. Thick
NASC CONTRACT NO.
N00019-72-C-0512
M.T. No. 061272-A
Plotted
Date
Fig. 131
MAXIMUM STRESS, ksi
MINIMUM STRESS, ksi

Fig. 131

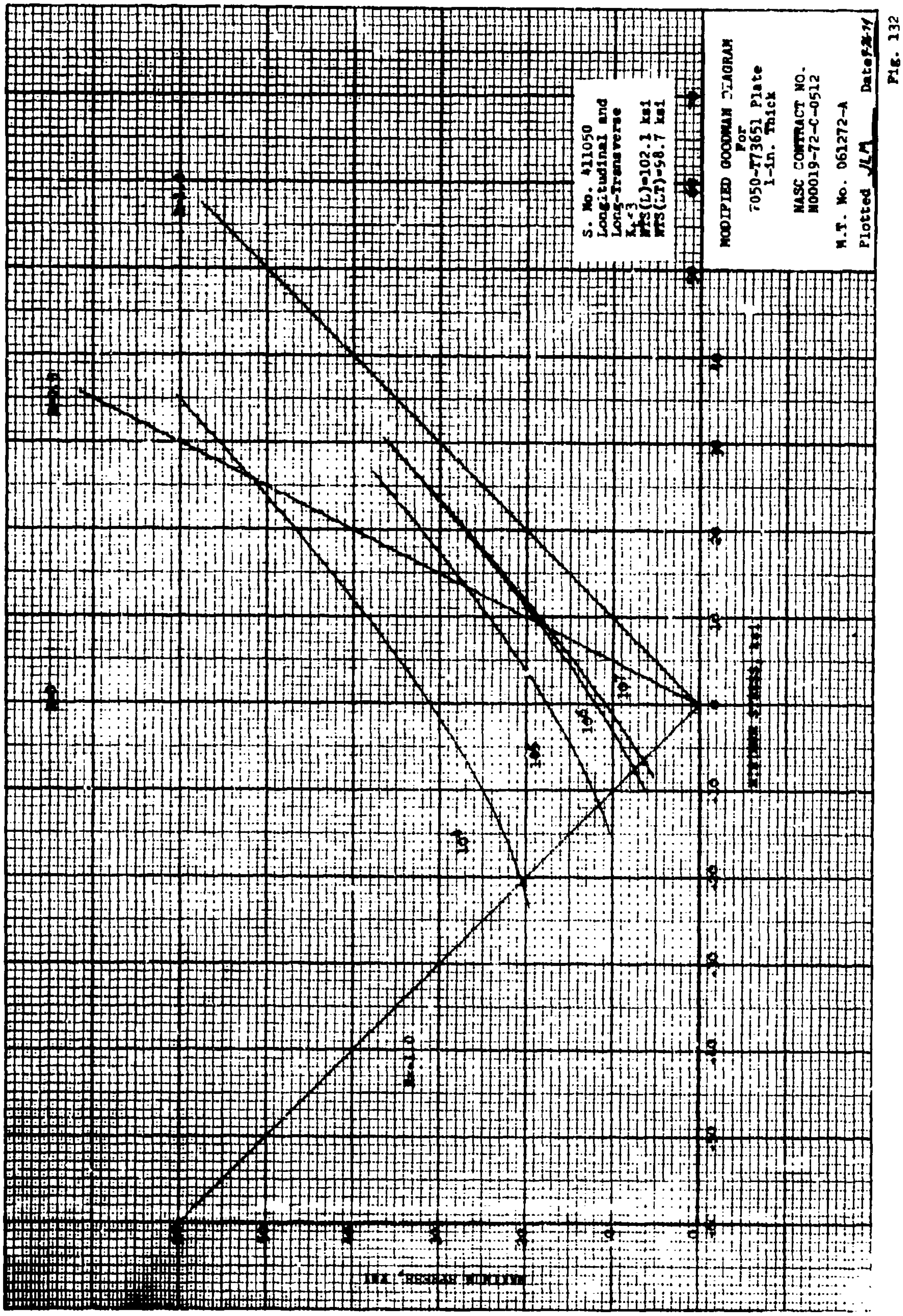

S. No. 411050
Longitudinal and Long-Transverse
MODIFIED GOODMAN DIAGRAM
For
7050-T73651 Plate
1-in. Thick
NASC CONTRACT NO.
N00019-72-C-0512
M.T. No. 061272-A
Plotted JLM
Fig. 132

Fig. 132

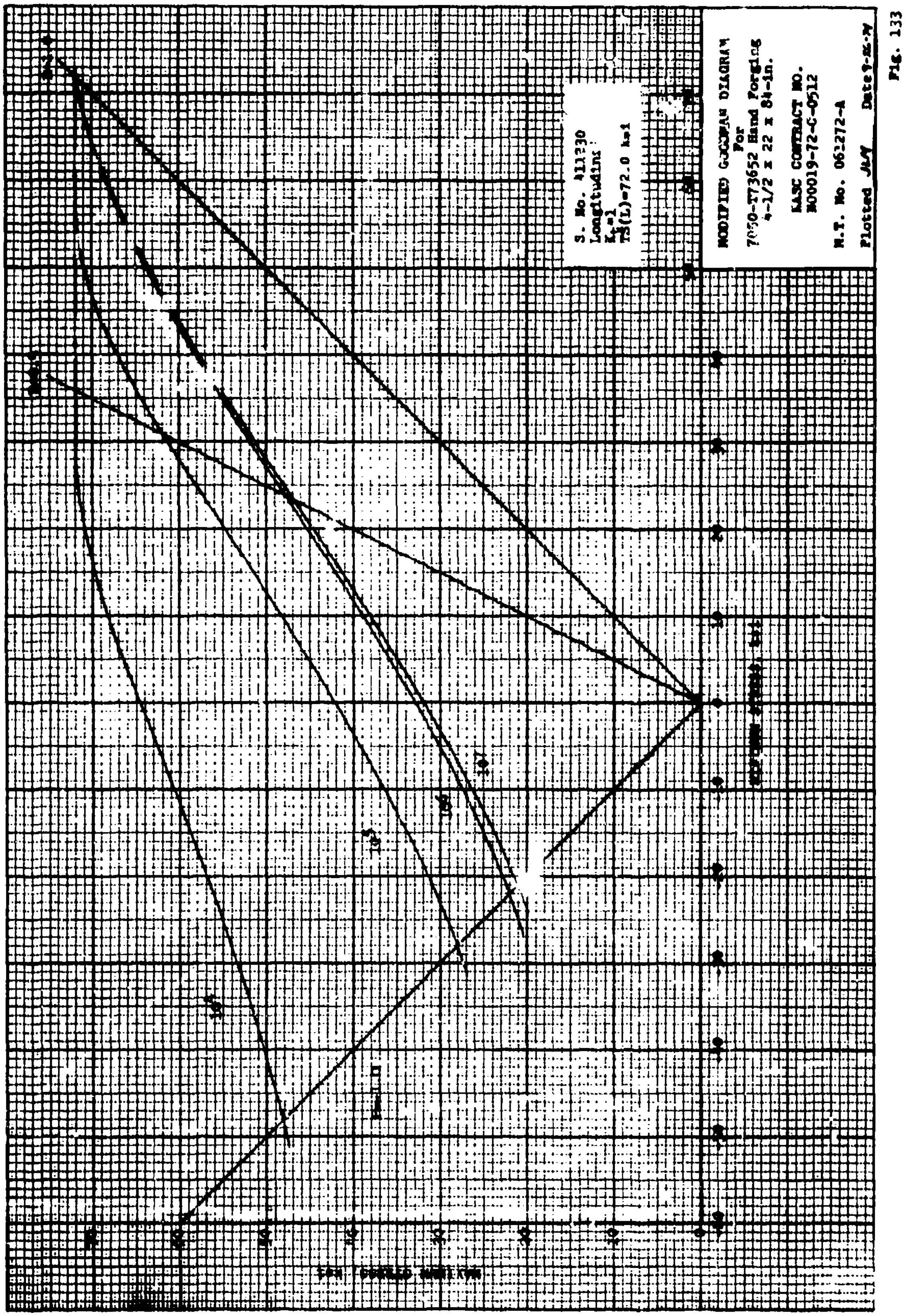

MODIFIED GOODMAN DIAGRAM
For
7050-T73652 Hand Forging
4-1/2 x 22 x 84-in.
NASC CONTRACT NO.
N00019-72-C-0512
M.T. No. 061272-A
S. No. 411330
Longitudinal
TS(L)=72.0 ksi
R=0
Fig. 133

Fig. 133

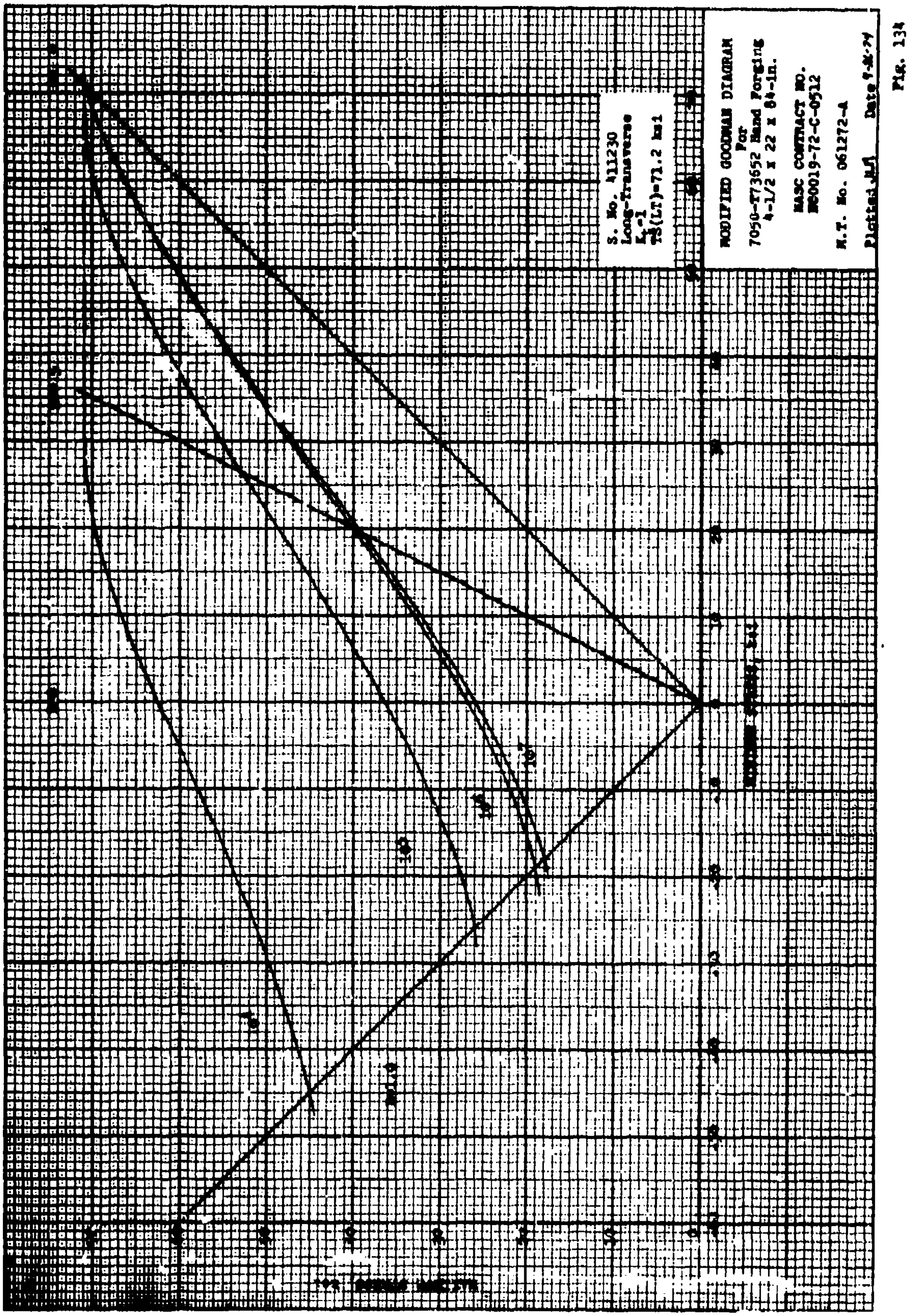

S. No. 411230
Long-Transverse
K_t=1
TS(LT)=71.2 ksi
MODIFIED GOODMAN DIAGRAM
For
7050-T73652 Hand Forging
4-1/2 x 22 x 84-in.
NASC CONTRACT NO.
N00019-72-C-0512
N.T. No. 061272-A
Fig. 134

Fig. 134

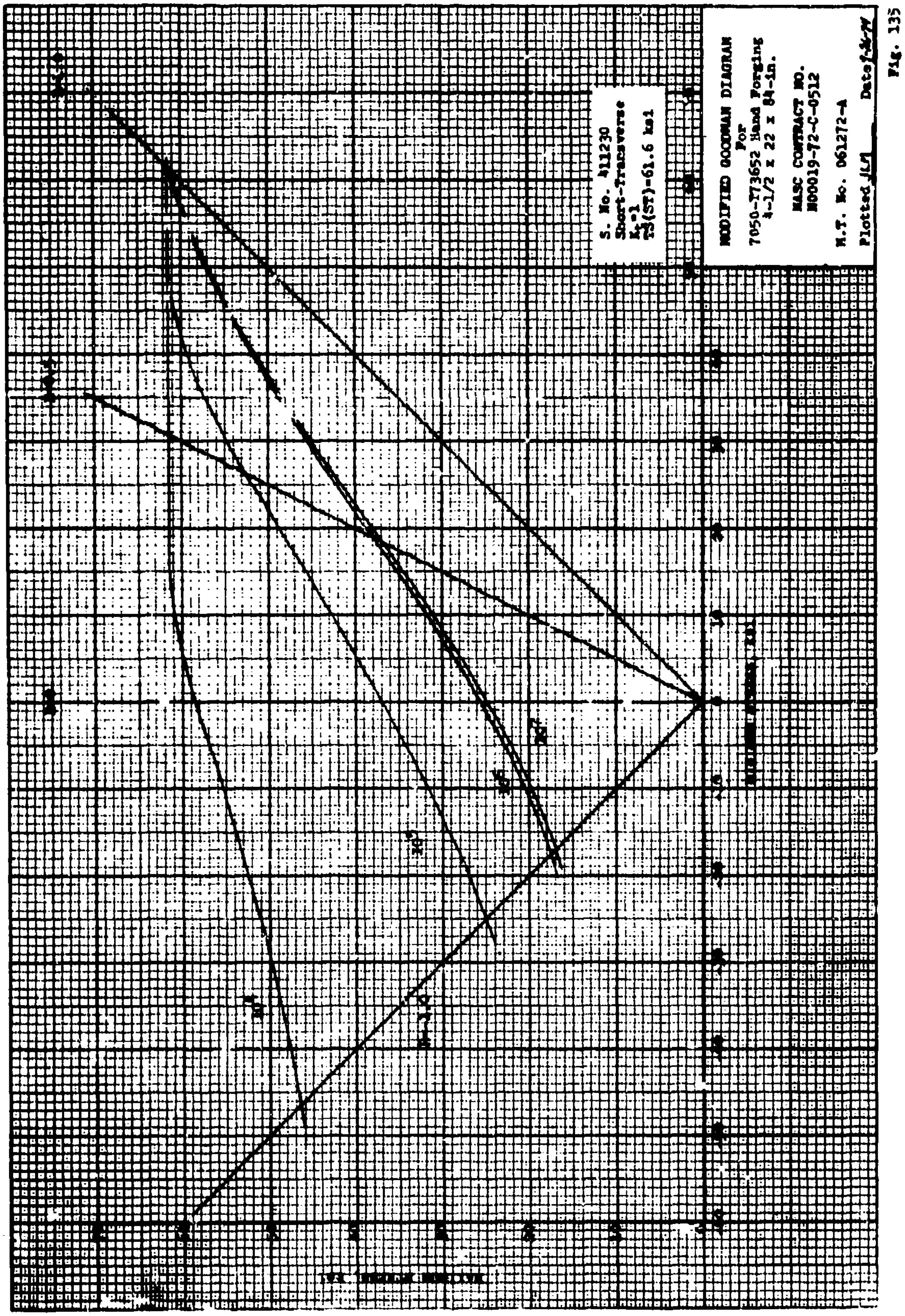

MODIFIED GOODMAN DIAGRAM
For
7050-T73652 Hand Forging
4-1/2 x 22 x 84-in.
NASC CONTRACT NO.
N00019-72-C-0512
M.T. No. 061272-A
S. No. 411230
Short-Transverse
TS(ST)=61.6 ksi

Fig. 135

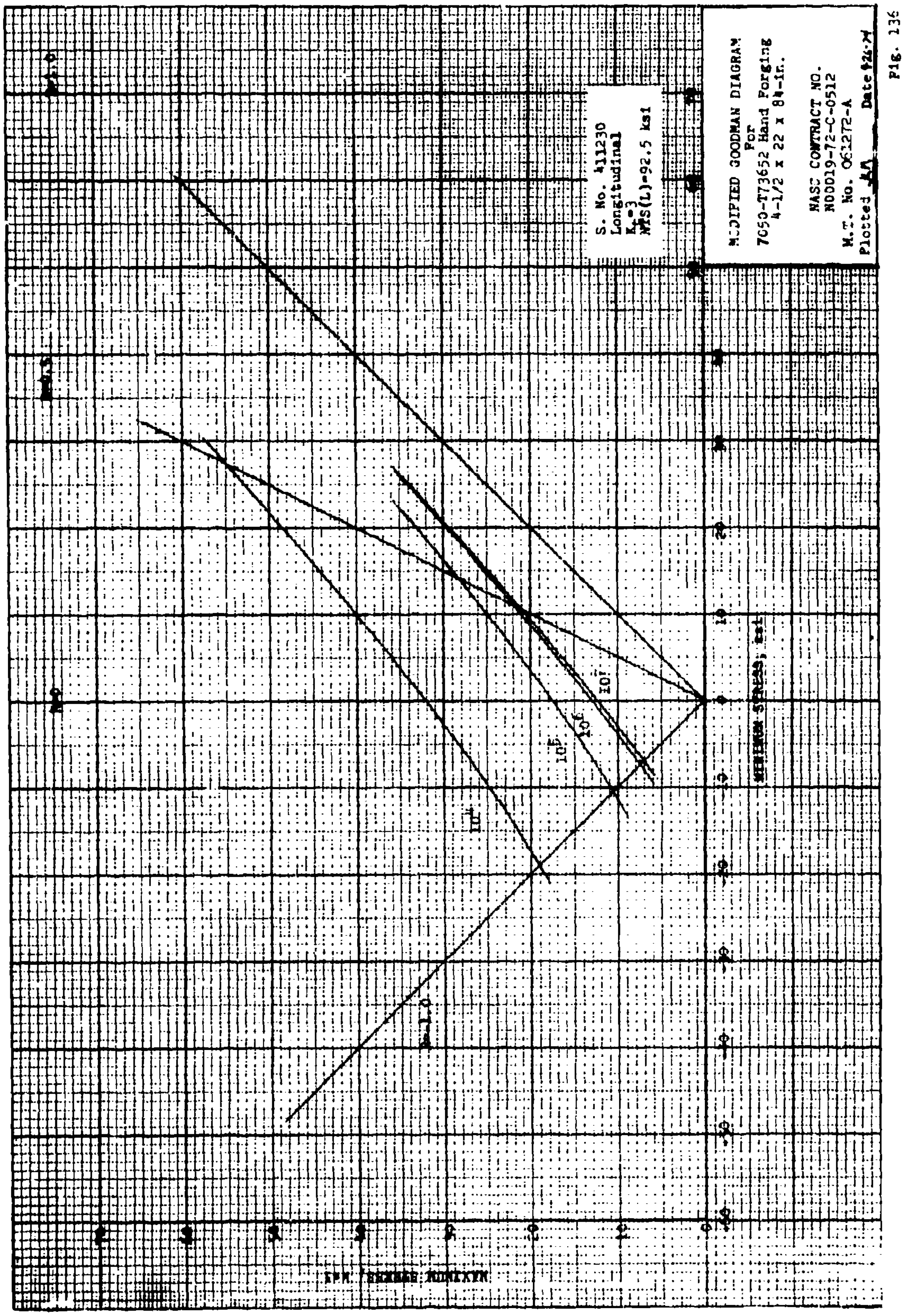

MODIFIED GOODMAN DIAGRAM
For
7050-T73652 Hand Forging
4-1/2 x 22 x 84-in.
NASC CONTRACT NO.
N00019-72-C-0512
M.T. No. 061272-A
S. No. 411230
Longitudinal
MINIMUM STRESS, ksi

Fig. 136

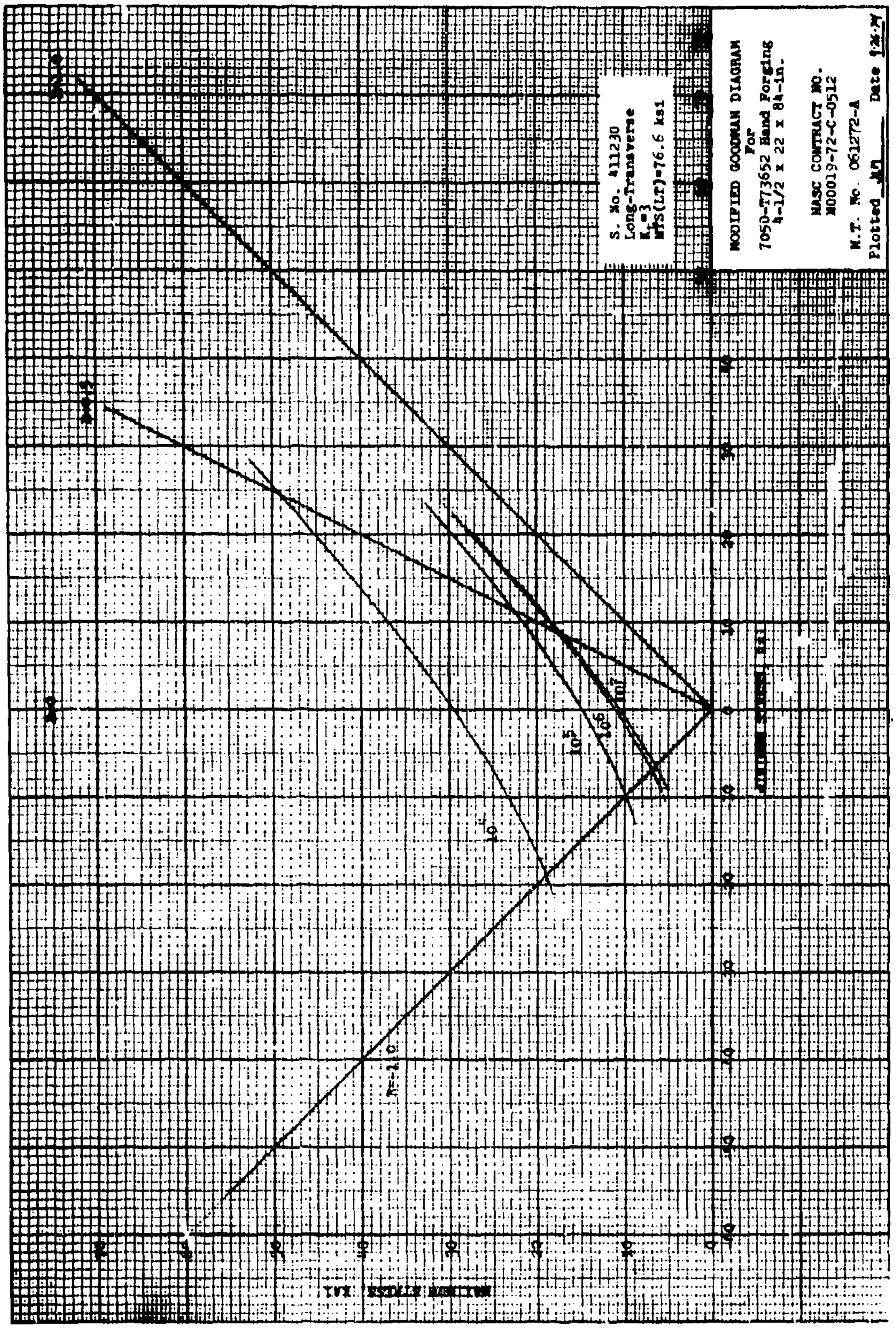
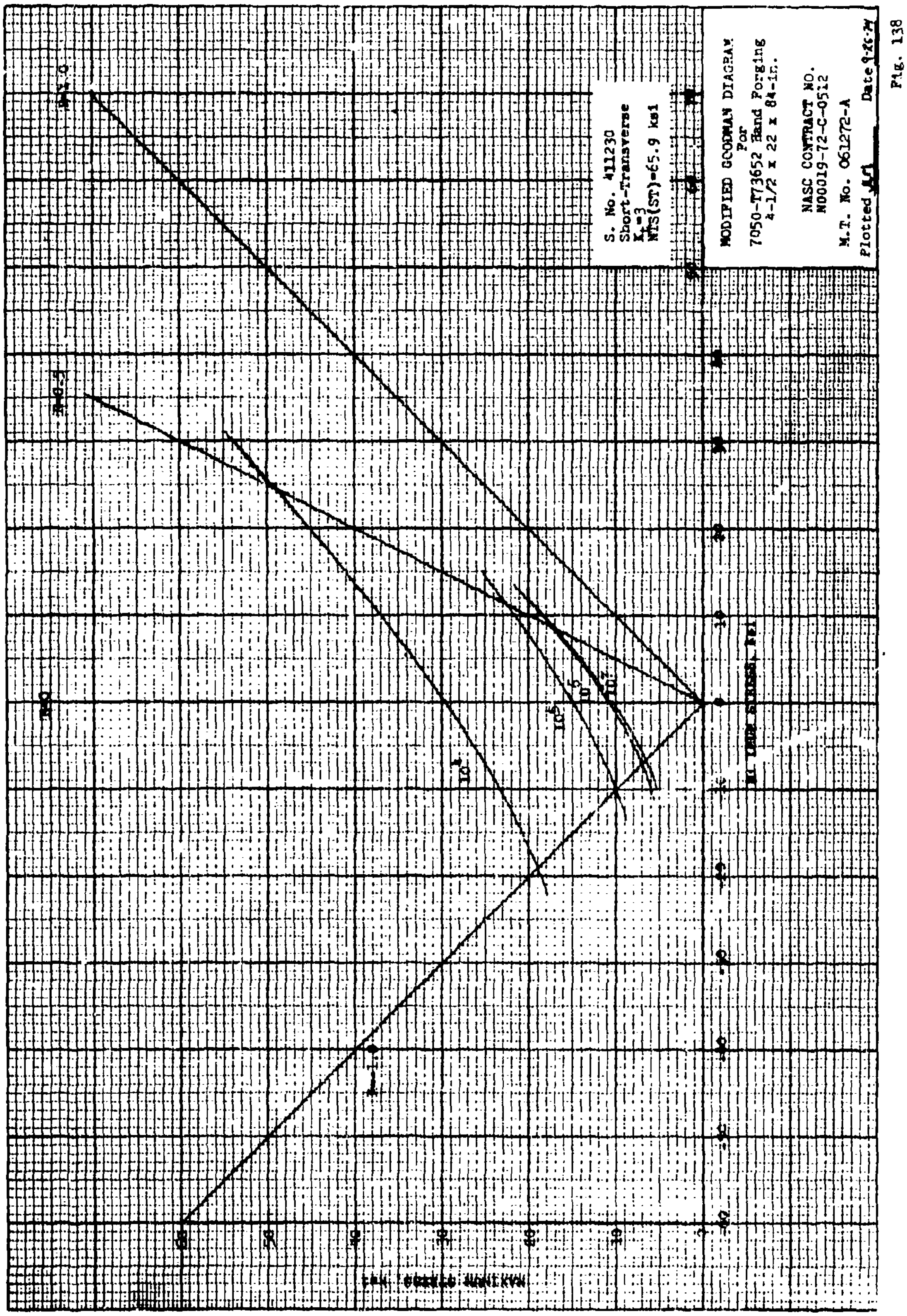

MODIFIED GOODMAN DIAGRAM
For
7050-T73652 Hand Forging
4-1/2 x 22 x 84-in.
NASC CONTRACT NO.
N00019-72-C-0512
W.T. No. 061272-A
Plotted
Date
Fig. 137
S. No. 411230
Long-Transverse
Kt=3
MTS(LT)=76.6 ksi
R=-1.0

Fig. 137



S. No. 411230
Short-Transverse
K_t=3
NTS(ST)=65.9 ksi
MODIFIED GOODMAN DIAGRAM
For
7050-T73652 Hand Forging
4-1/2 x 22 x 84-in.
NASC CONTRACT NO.
N00019-72-C-0512
M.T. No. 061272-A
Plotted
Date
Fig. 138
10^4
10^5
10^6
10^7

Fig. 138

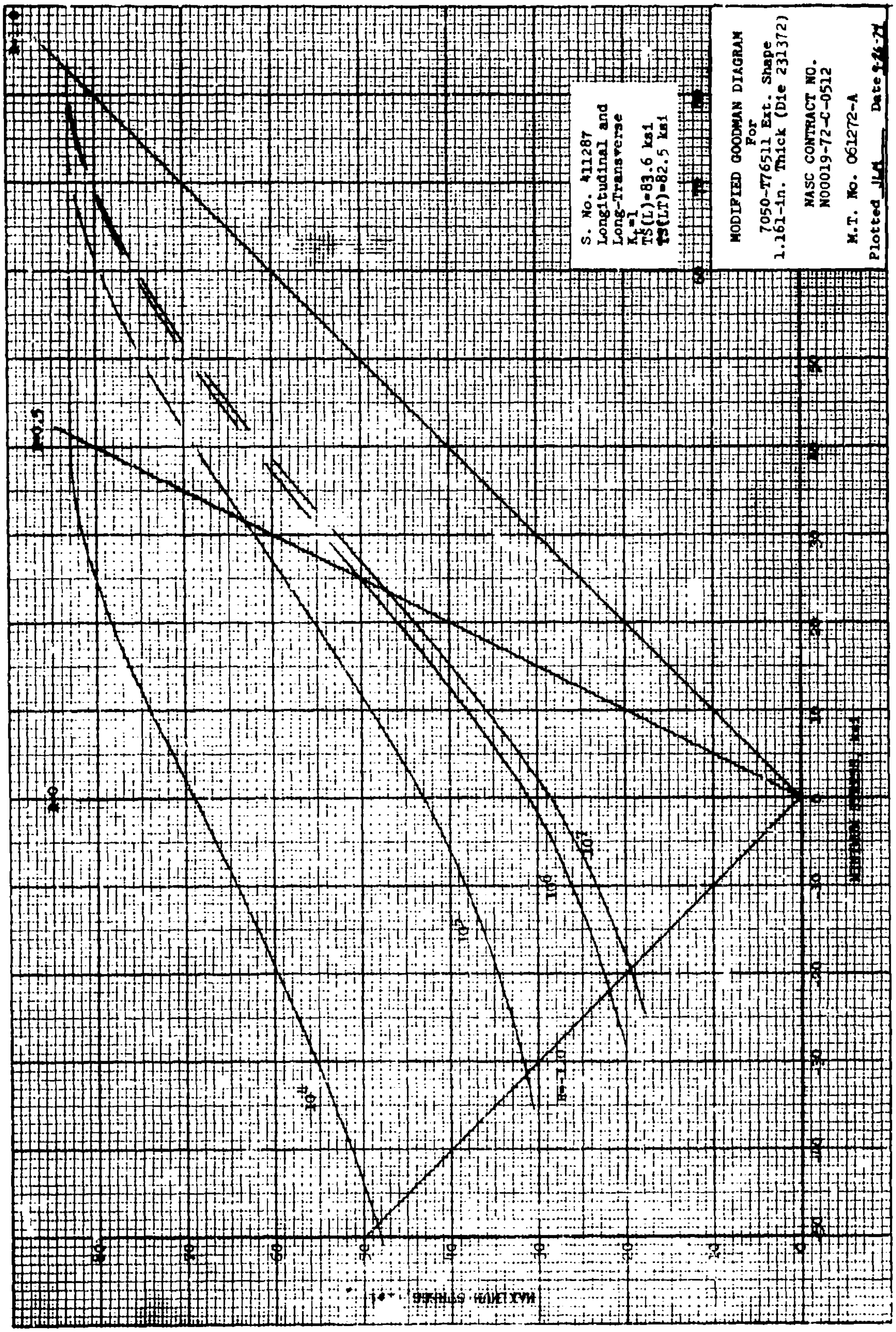
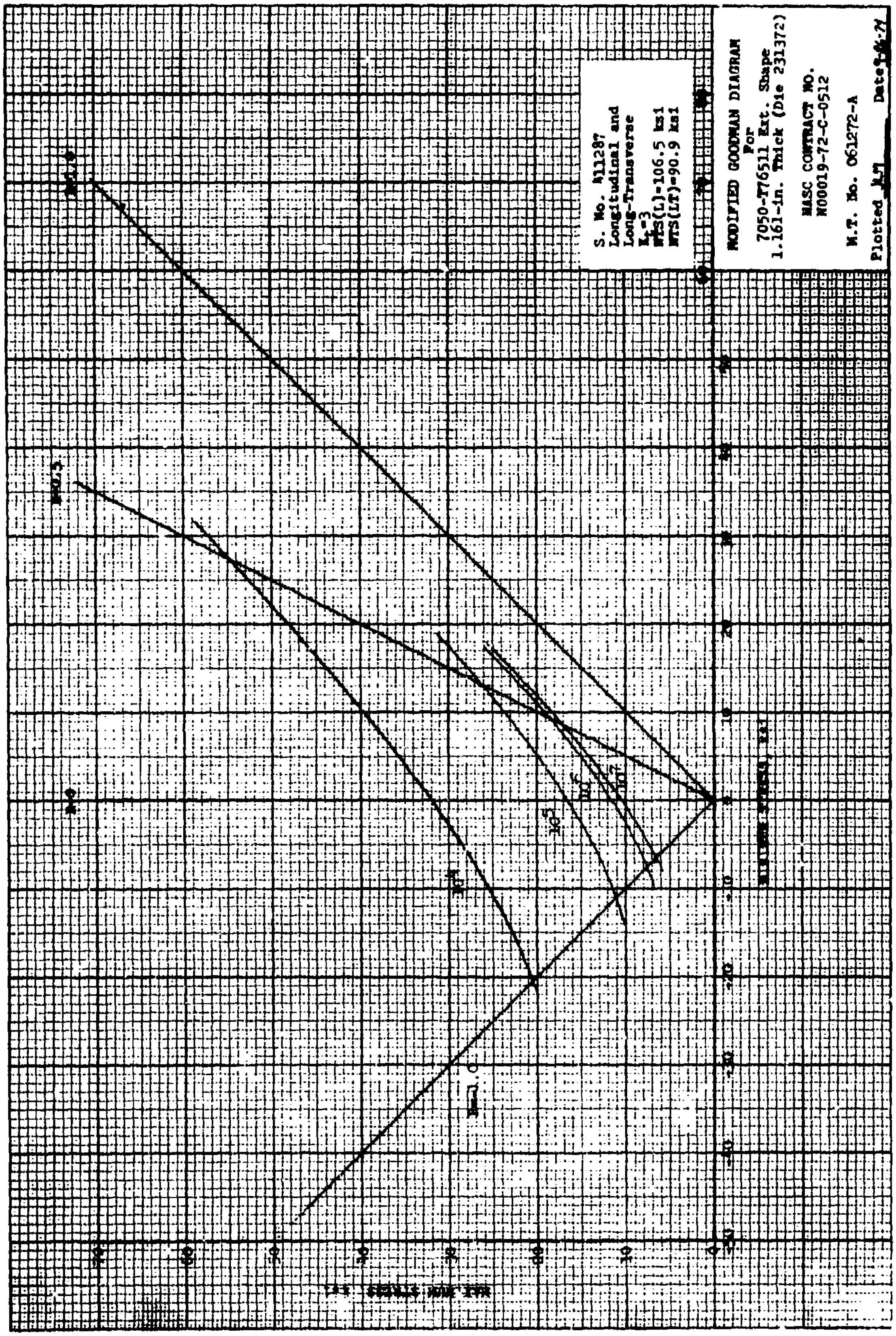
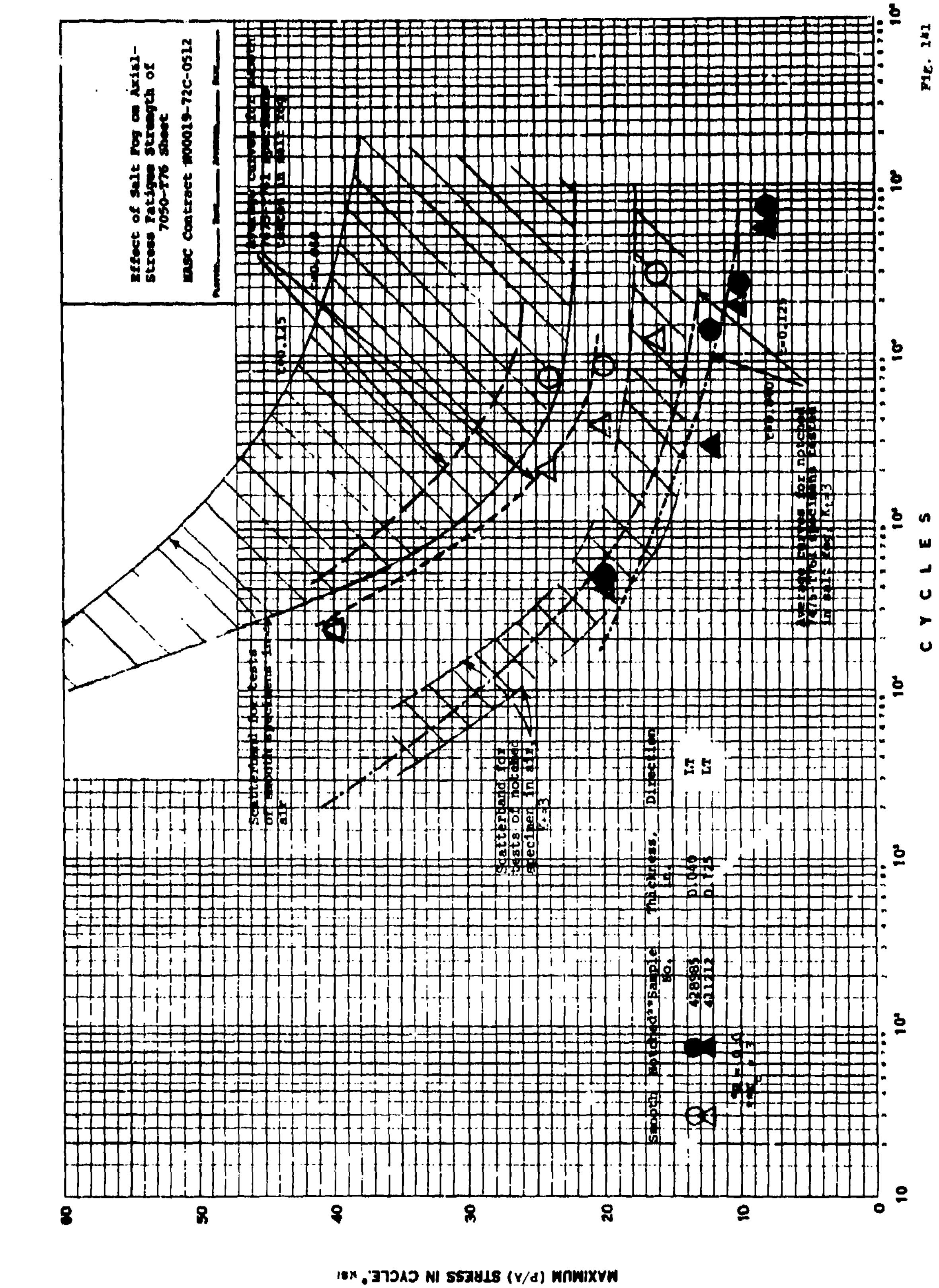

S. No. 411287
Longitudinal and
Long-Transverse
K_t=1
TS(L)=83.6 ksi
TS(LT)=82.5 ksi
MODIFIED GOODMAN DIAGRAM
For
7050-T76511 Ext. Shape
1.161-in. Thick (Die 231372)
NASC CONTRACT NO.
N00019-72-C-0512
M.T. No. 061272-A
Plotted
Date
MAXIMUM STRESS, ksi
MINIMUM STRESS, ksi
R=1.0
R=0.5
R=0
R=-1.0
10^4
10^5
10^6
10^7

Fig. 139



S. No. N11287
Longitudinal and
Long-Transverse
K_t=3
NTS(L)=106.5 ksi
NTS(LT)=90.9 ksi
MODIFIED GOODMAN DIAGRAM
For
7050-T76511 Ext. Shape
1.161-in. Thick (Die 231372)
NASC CONTRACT NO.
N00019-72-C-0512
M.T. No. 061272-A
Plotted
Date
Fig. 140
10^4
10^5
10^6
10^7
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50

Fig. 140



Effect of Salt Fog on Axial-Stress Fatigue Strength of 7050-T76 Sheet
NASC Contract N00019-72C-0512
MAXIMUM (P/A) STRESS IN CYCLE, ksi
C Y C L E S
Scatterband for tests of smooth specimens in air
Scatterband for tests of notched specimen in air K_t=3
Average curves for notched (K_t=3) specimens tested in salt fog
Smooth Notched Sample No. Thickness, in. Direction
428985 0.040 LT
431212 0.125 LT
Fig. 141

Fig. 141

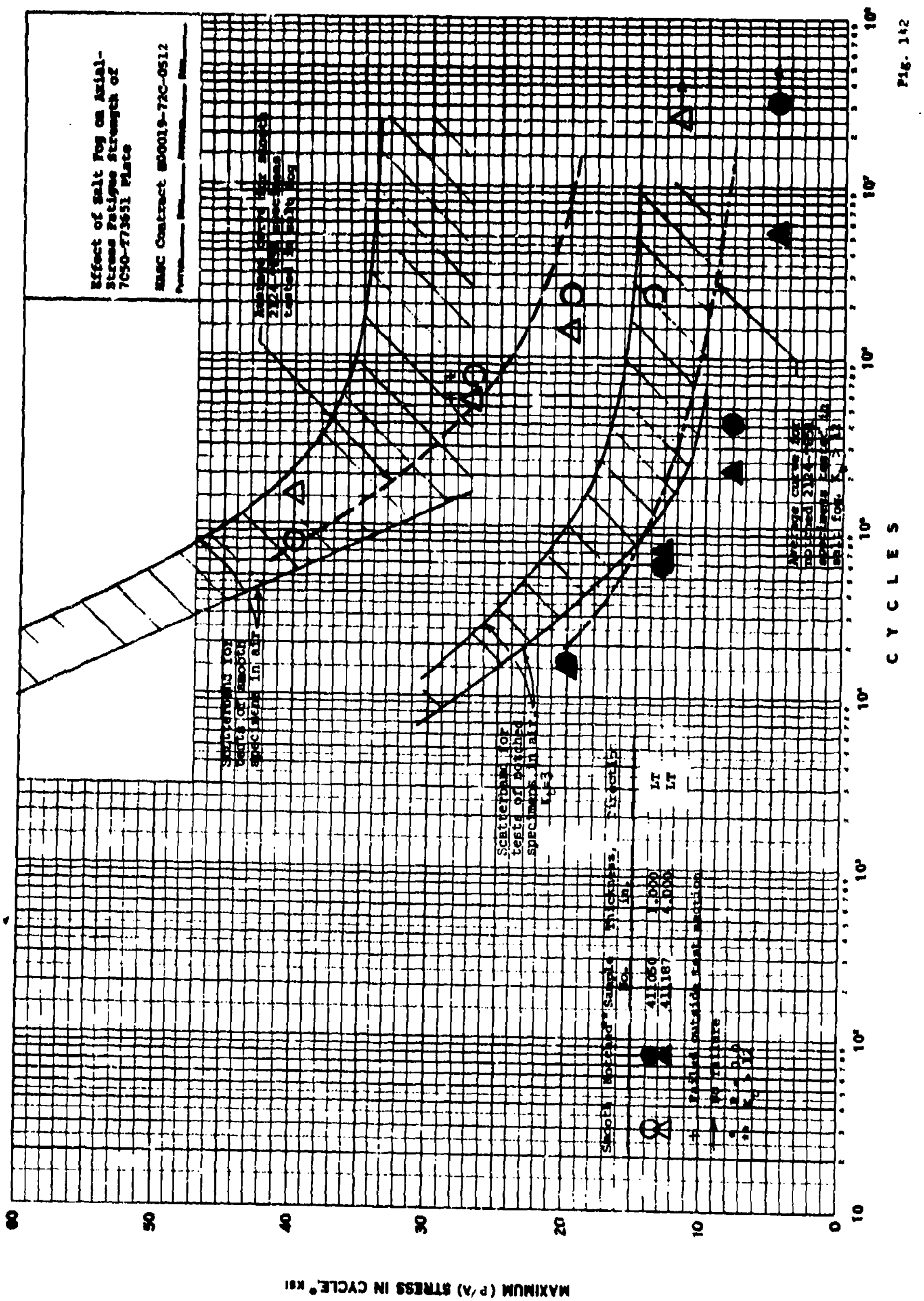

Effect of Salt Fog on Axial-Stress Fatigue Strength of 7C50-T73651 Plate
CYCLES
MAXIMUM (P/A) STRESS IN CYCLE, ksi
Scatterband for tests of smooth specimens in air
Scatterband for tests of notched specimens in air, Kt=3
0
10
20
30
40
50
60
10
10²
10³
10⁴
10⁵
10⁶
10⁷
10⁸

Fig. 142

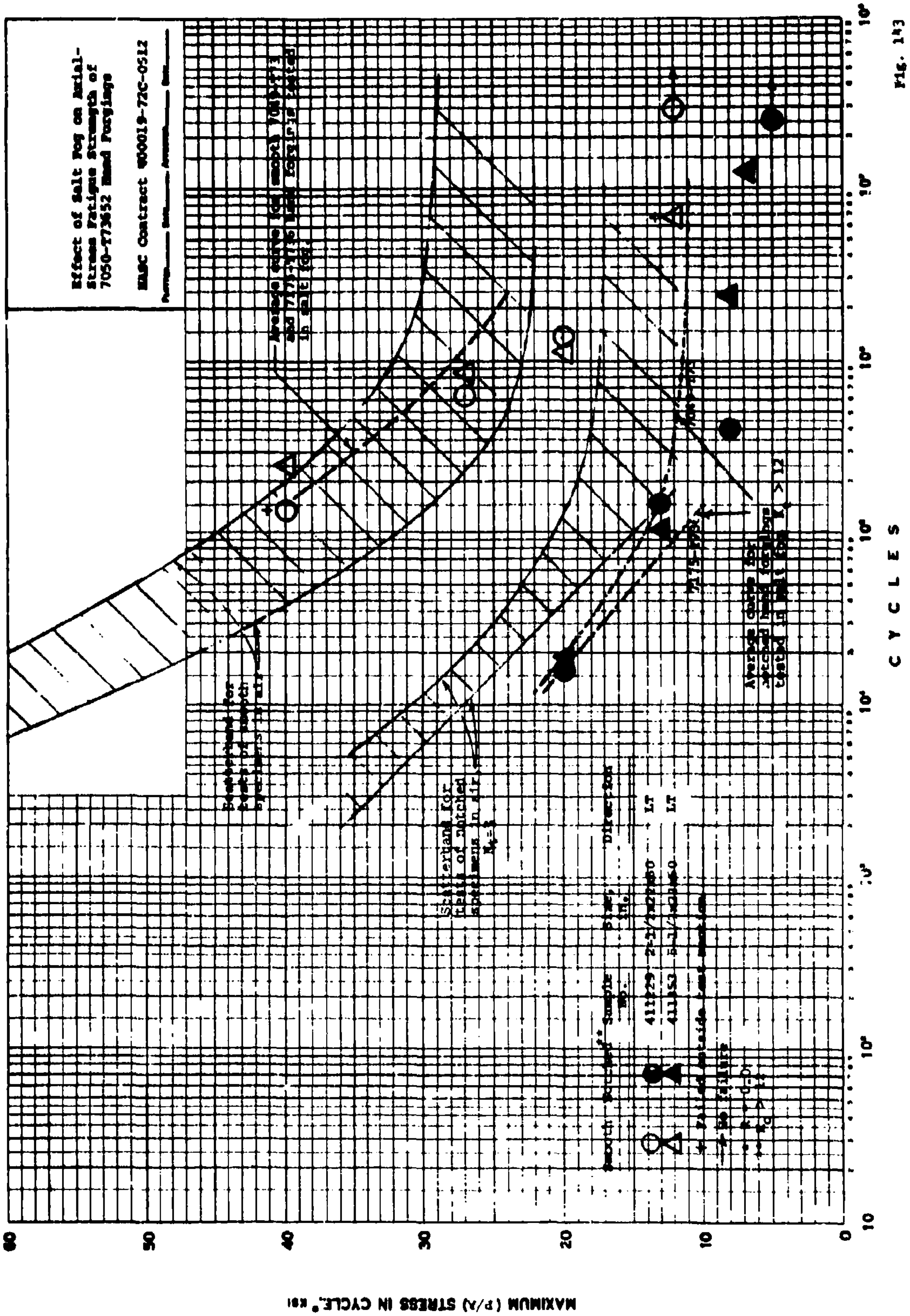

Effect of Salt Fog on Axial-Stress Fatigue Strength of 7050-T73652 Hand Forgings
NASC Contract N00019-72C-0512
C Y C L E S
MAXIMUM (P/A) STRESS IN CYCLE, ksi
Fig. 143

Fig. 143

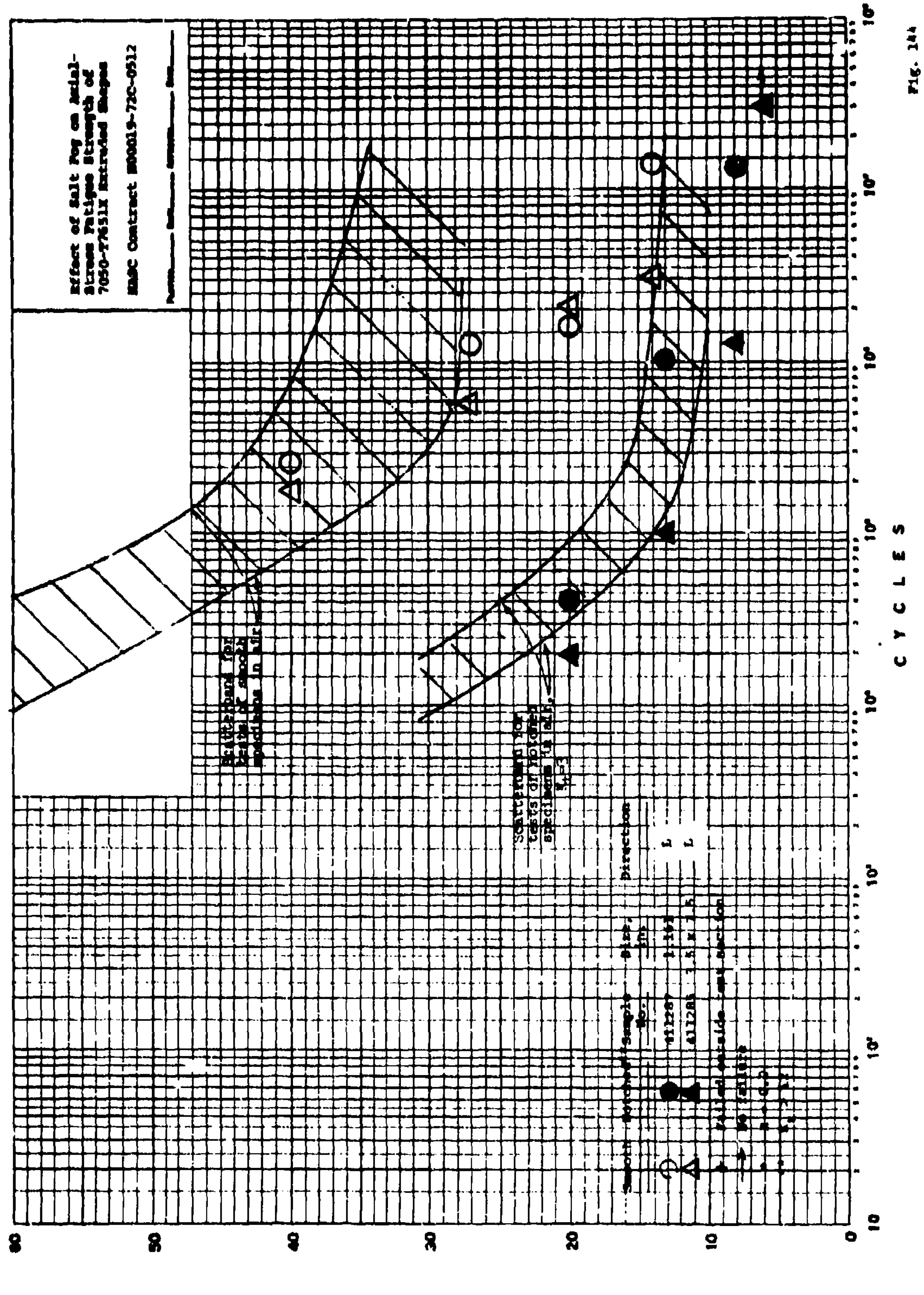

Effect of Salt Fog on Axial-Stress Fatigue Strength of 7050-T7651X Extruded Shapes
NASC Contract N00019-72C-0512
Scatterband for tests of smooth specimens in air
Scatterband for tests of notched specimens in air
Direction
L
L
C Y C L E S
MAXIMUM (P/A) STRESS IN CYCLE, ksi
Fig. 144

Fig. 144

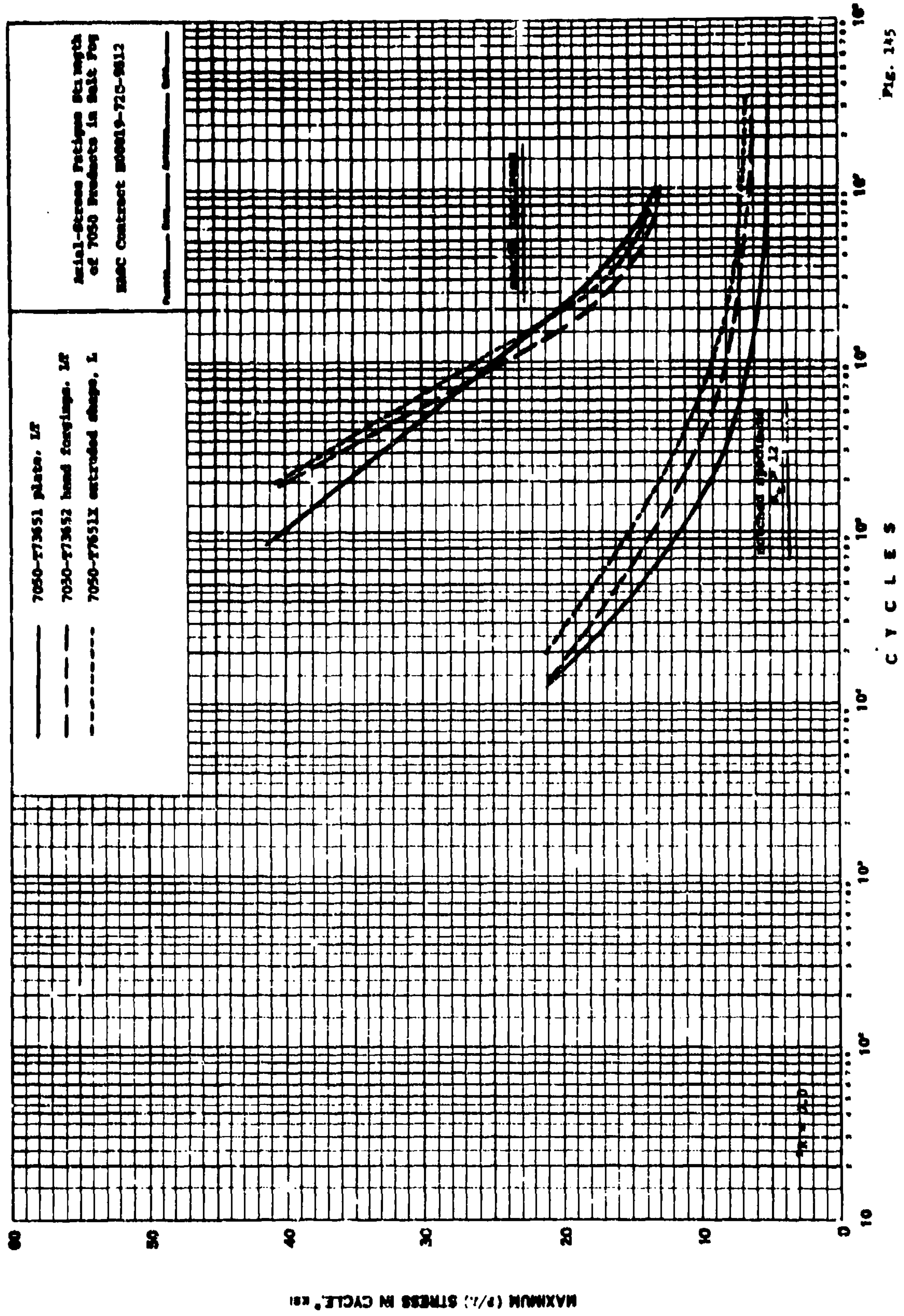

Axial-Stress Fatigue Strength of 7050 Products in Salt Fog
7050-T73651 plate, LT
7050-T73652 hand forgings, LT
7050-T76511 extruded shape, L
CYCLES
MAXIMUM (P/A) STRESS IN CYCLE, ksi

Fig. 145

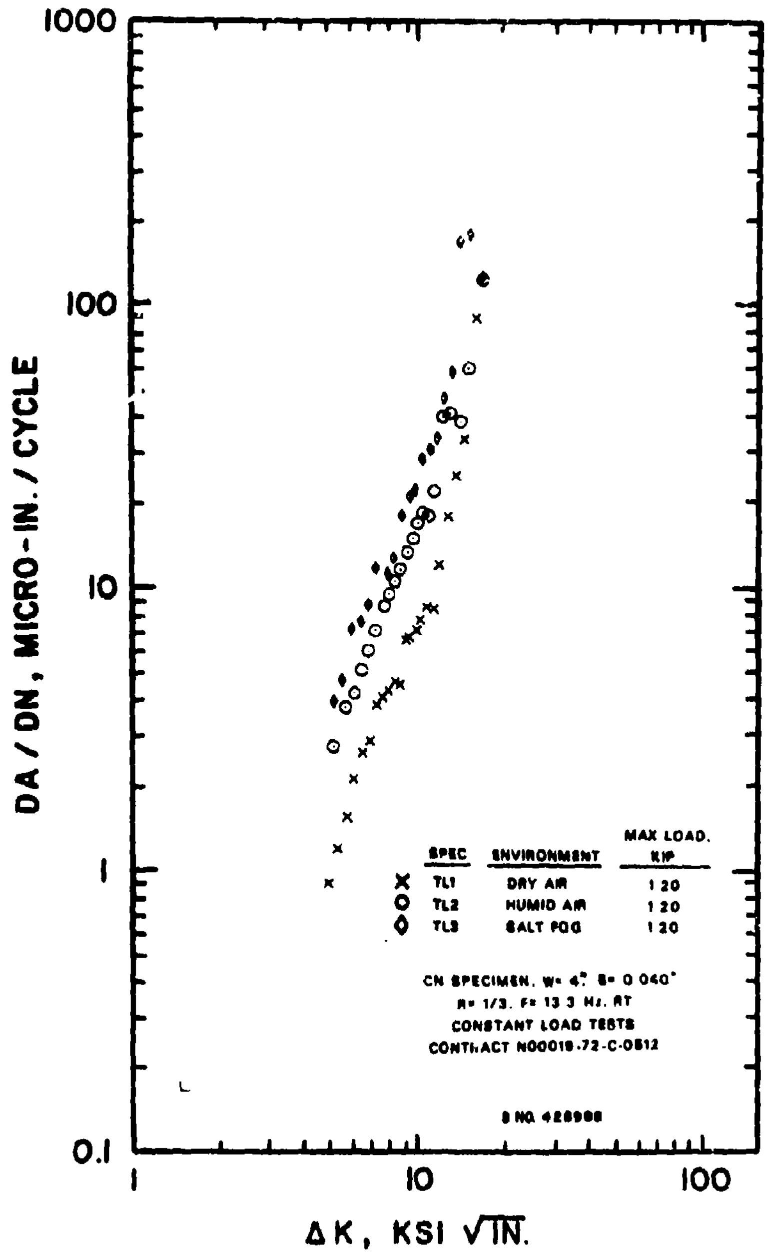


Fig. 146 **FATIGUE CRACK-GROWTH DATA FOR 0.040-IN. 7050-T76 SHEET. T-L ORIENTATION**

Fig. 146

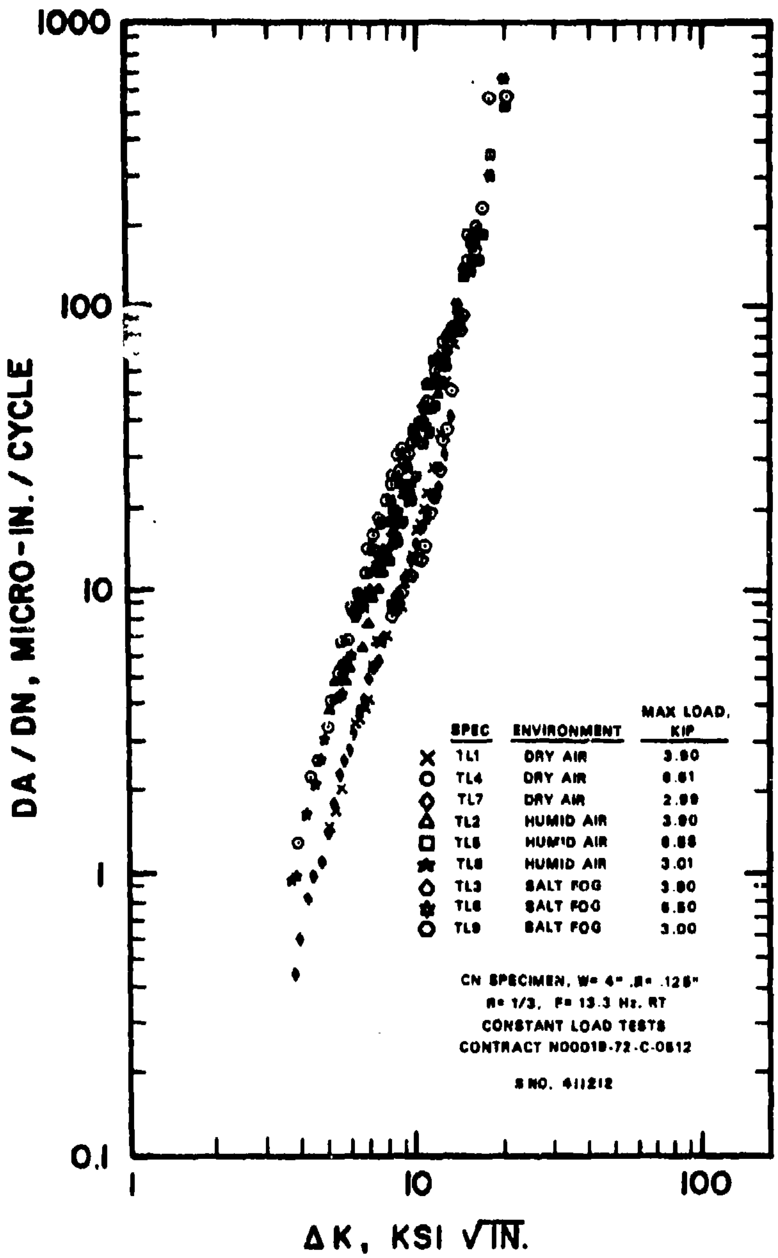


Fig. 147 **FATIGUE CRACK-GROWTH DATA FOR 0.125-IN. 7050-T76 SHEET. T-L ORIENTATION**

Fig. 147

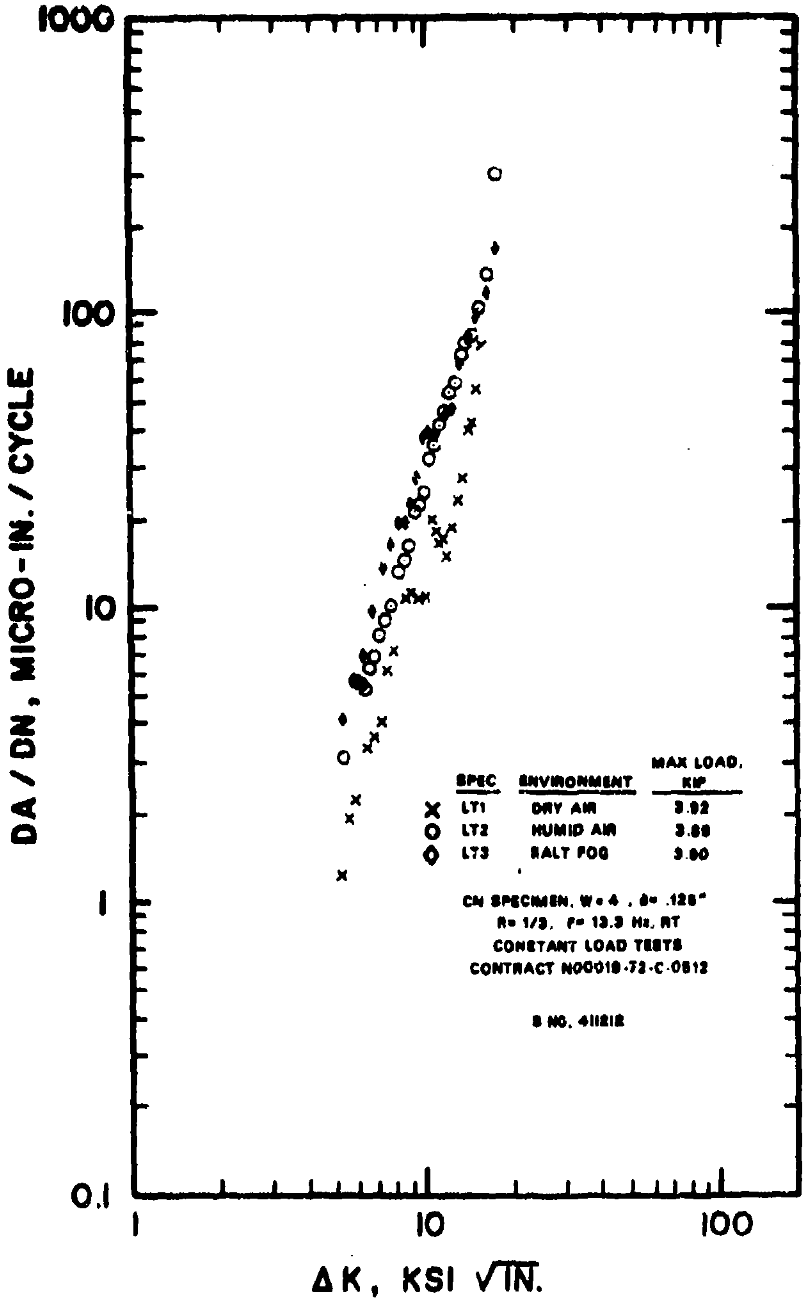


Fig. 148 FATIGUE CRACK-GROWTH DATA FOR 0.125-IN. 7050-T76 SHEET. L-T ORIENTATION

Fig. 148

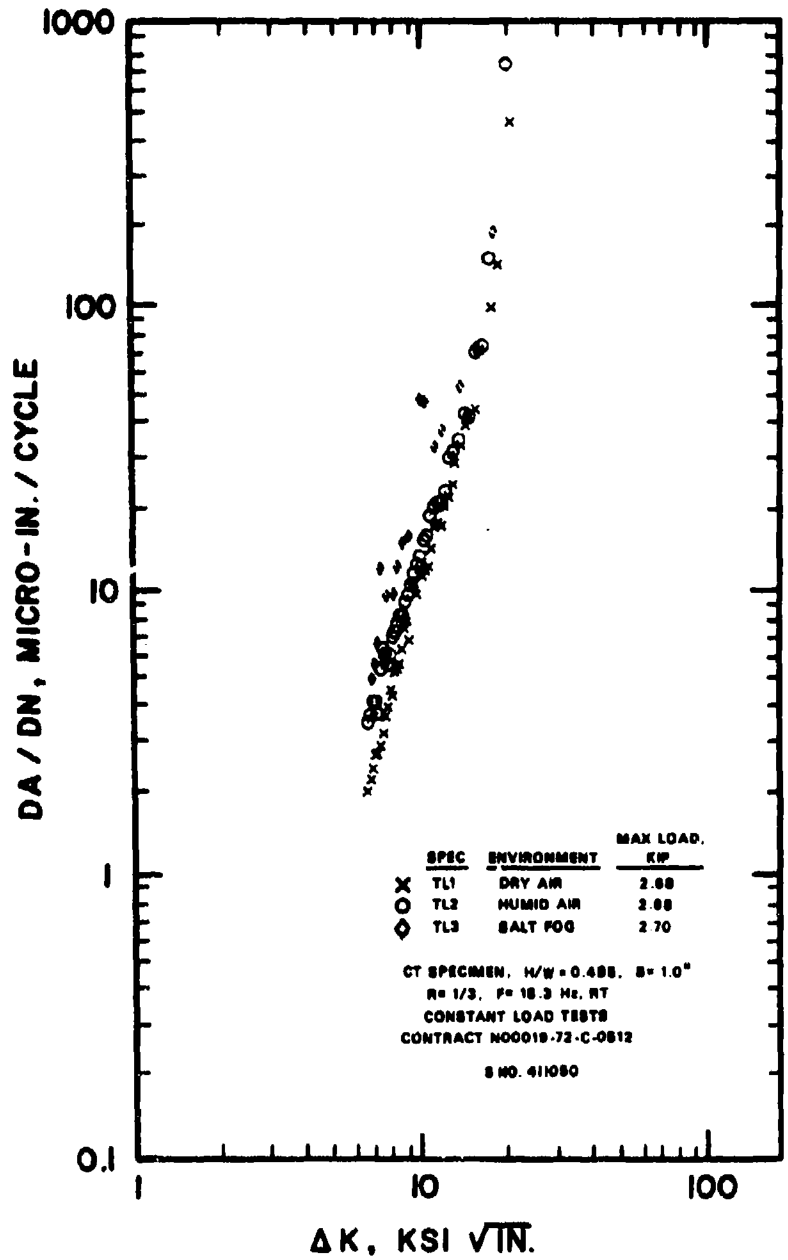


Fig. 149 FATIGUE CRACK-GROWTH DATA FOR
1-IN. 7050-T73651 PLATE.
T-L ORIENTATION

Fig. 149

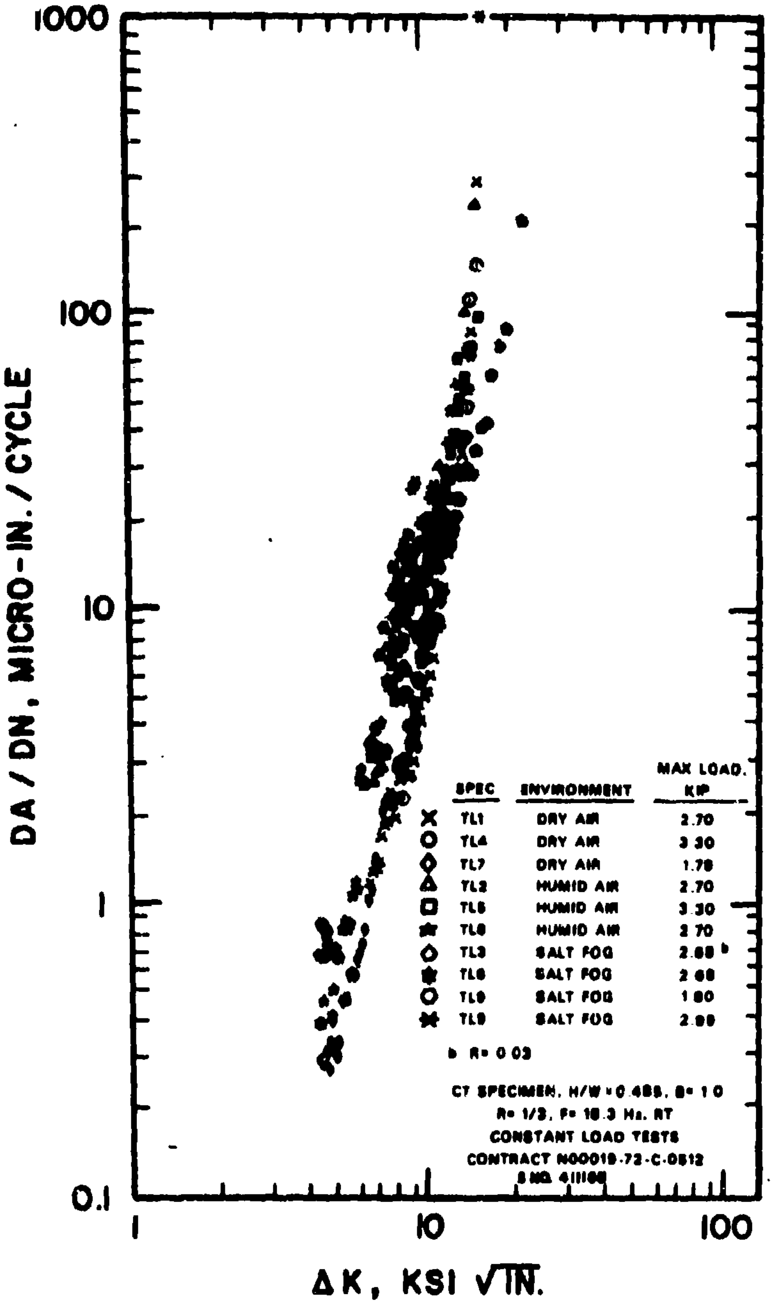


Fig. 150 **FATIGUE CRACK-GROWTH DATA FOR 6-IN. 7050-T73651 PLATE. T-L ORIENTATION**

Fig. 150

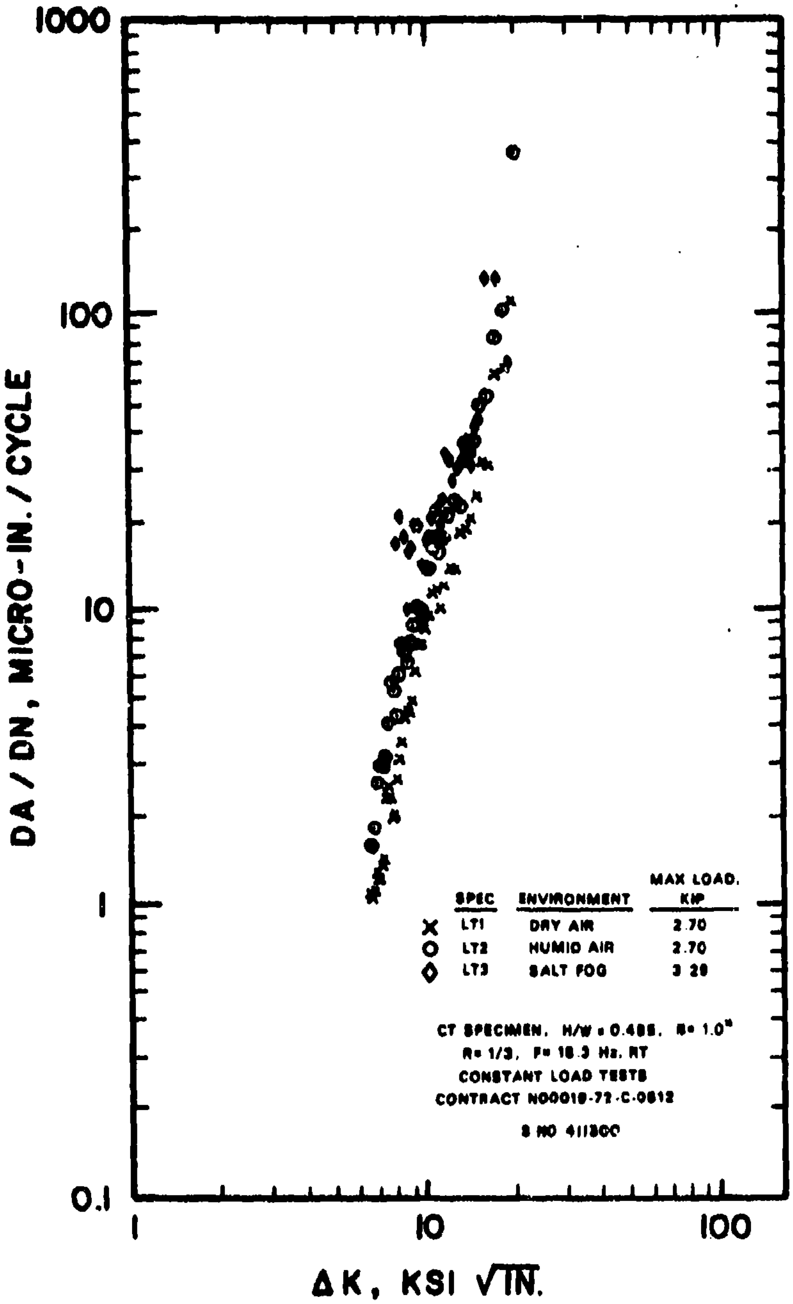


Fig. 151 **FATIGUE CRACK-GROWTH DATA FOR 6-IN. 7050-T73651 PLATE. L-T ORIENTATION**

Fig. 151

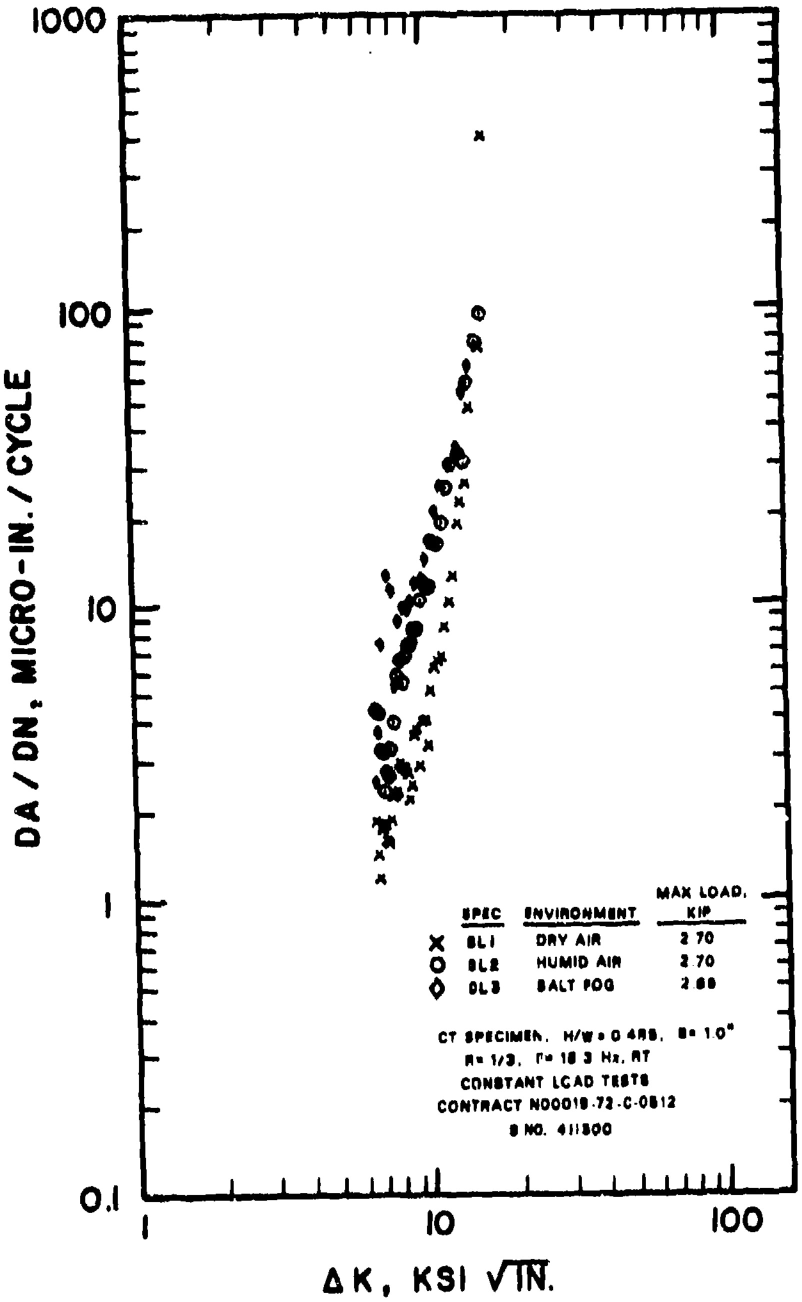


Fig. 152 FATIGUE CRACK-GROWTH DATA FOR 6-IN. 7050-T73651 PLATE. S-L ORIENTATION

Fig. 152

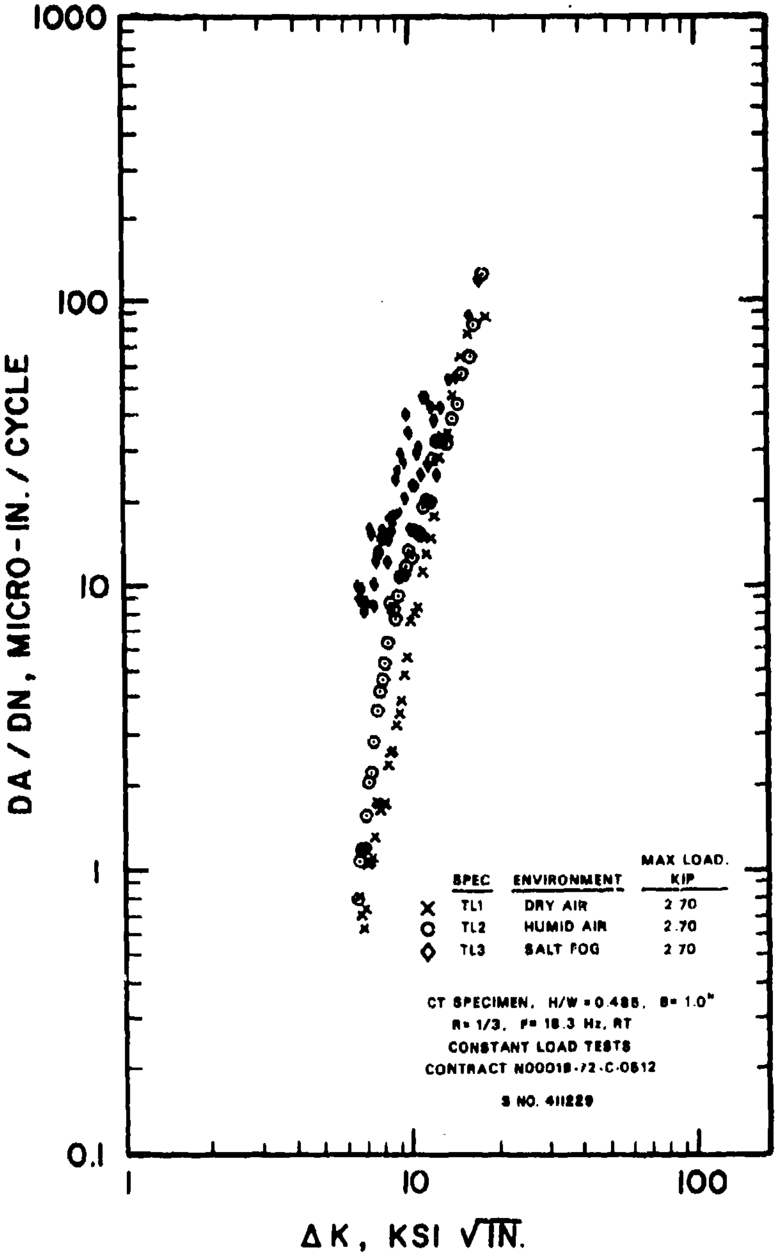


Fig. 153 **FATIGUE CRACK-GROWTH DATA FOR 2-1/2 x 22-IN. 7050-T73652 HAND FORGING T-L ORIENTATION**

Fig. 1[illegible]

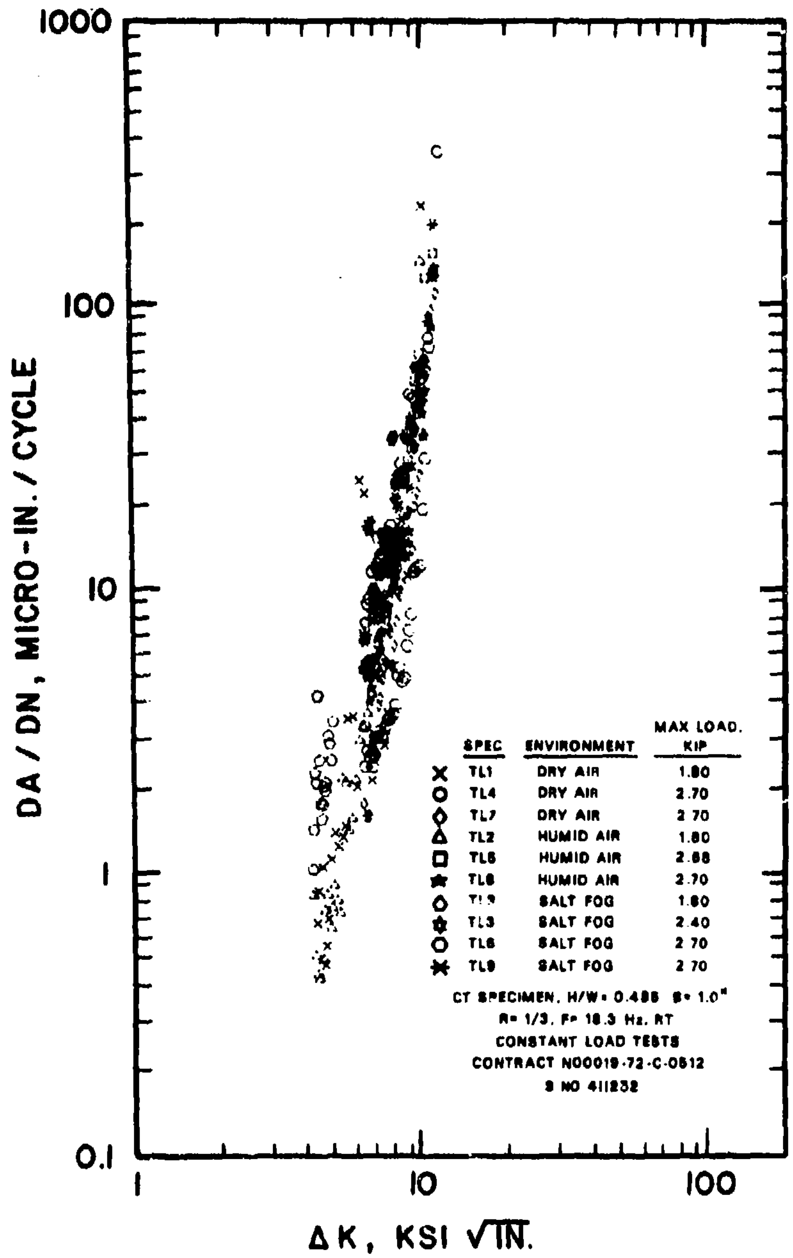


Fig. 154 **FATIGUE CRACK-GROWTH DATA FOR 7-1/2 x 22-IN. 7050-T73652 HAND FORGING. T-L ORIENTATION**

Fig. 154

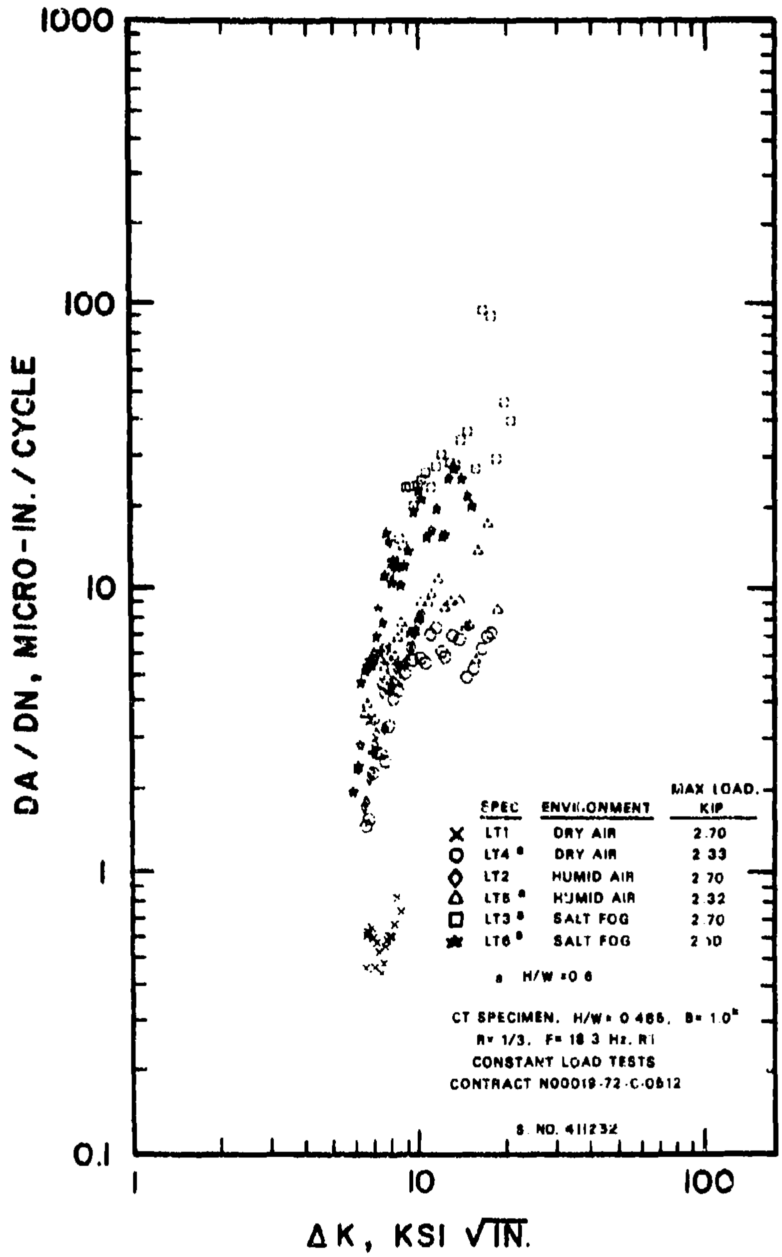


Fig. 155 FATIGUE CRACK-GROWTH DATA FOR 7-1/2 x 22-IN. 7050-T73652 HAND FORGING. L-T ORIENTATION

Fig. 155

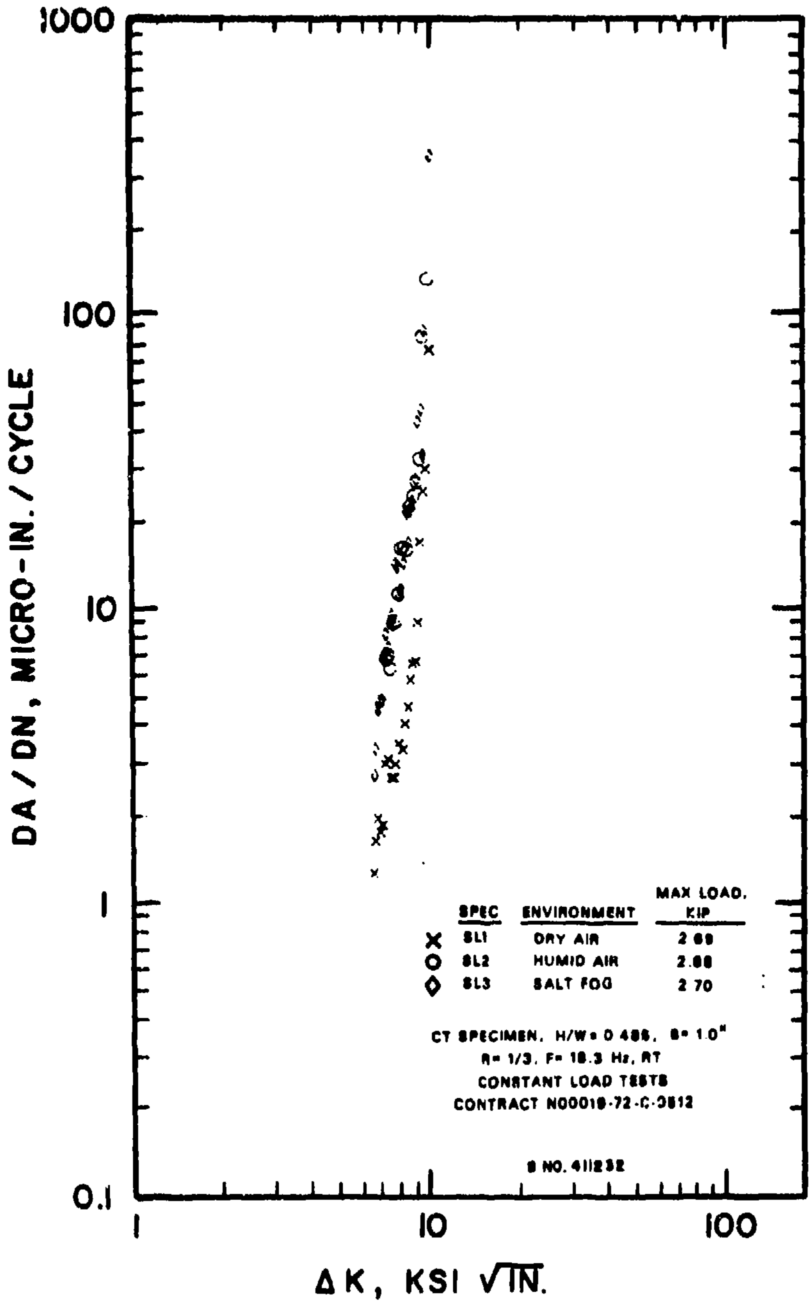


Fig. 156 **FATIGUE CRACK-GROWTH DATA FOR 7-1/2 x 22-IN. 7050-T73652 HAND FORGING. S-L ORIENTATION**

Fig. 156

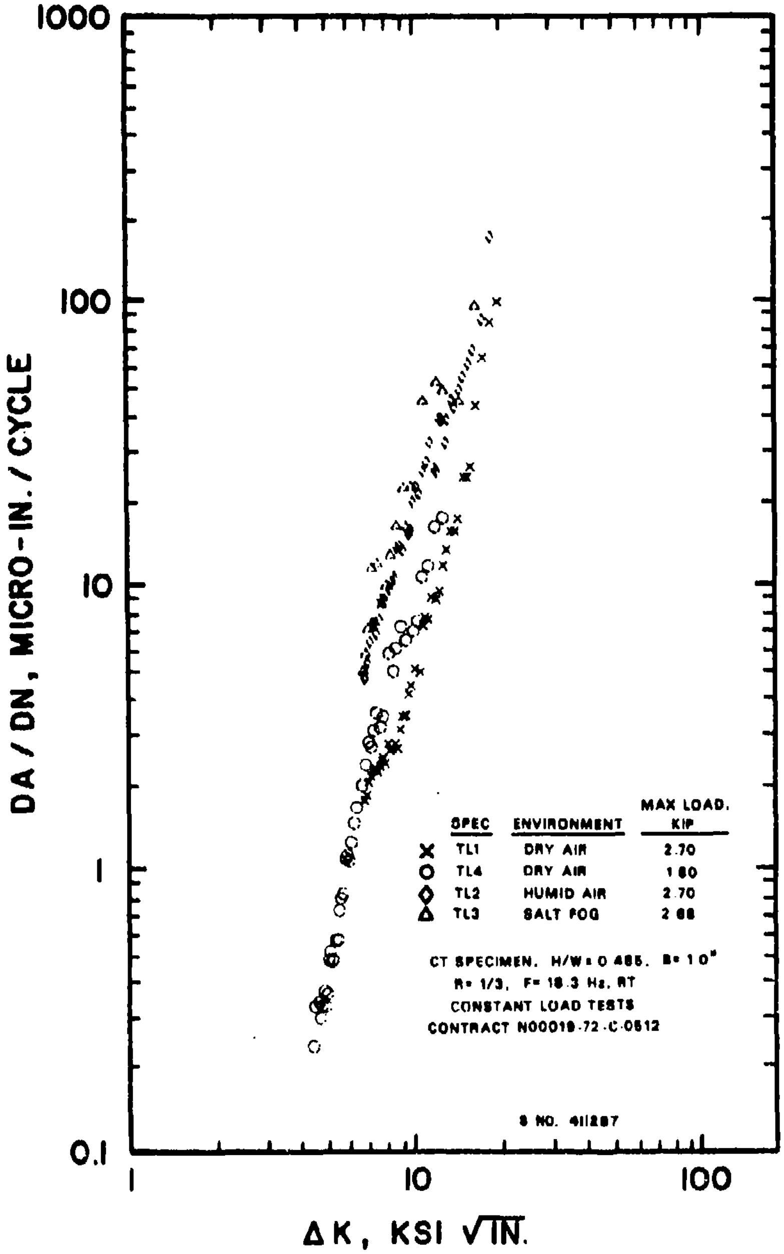


Fig. 157 FATIGUE CRACK-GROWTH DATA FOR 1.161-IN. 7050-T76511 EXTRUDED SHAPE. T-L ORIENTATION

Fig. 157

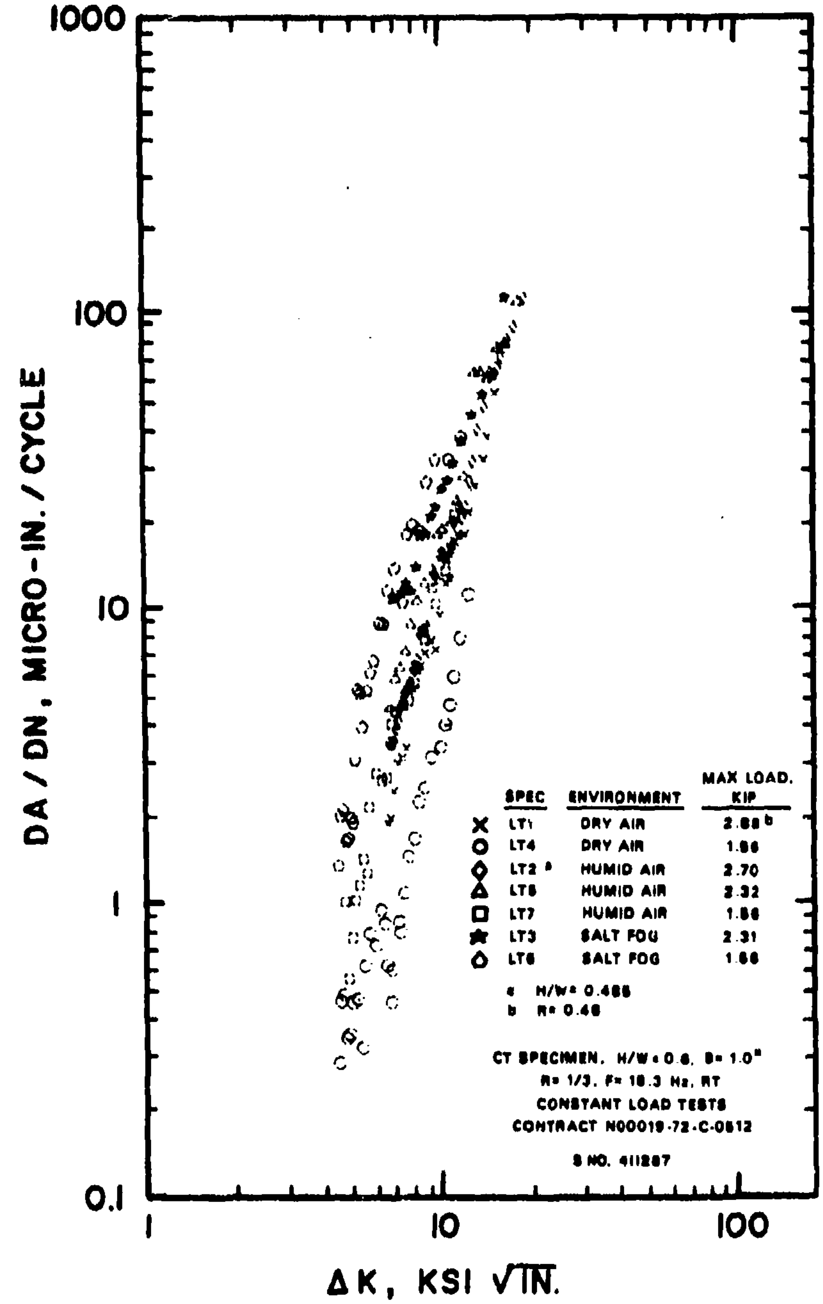


Fig. 158 **FATIGUE CRACK-GROWTH DATA FOR 1.161-IN. 7050-T76511 EXTRUDED SHAPE. L-T ORIENTATION**

Fig. 158

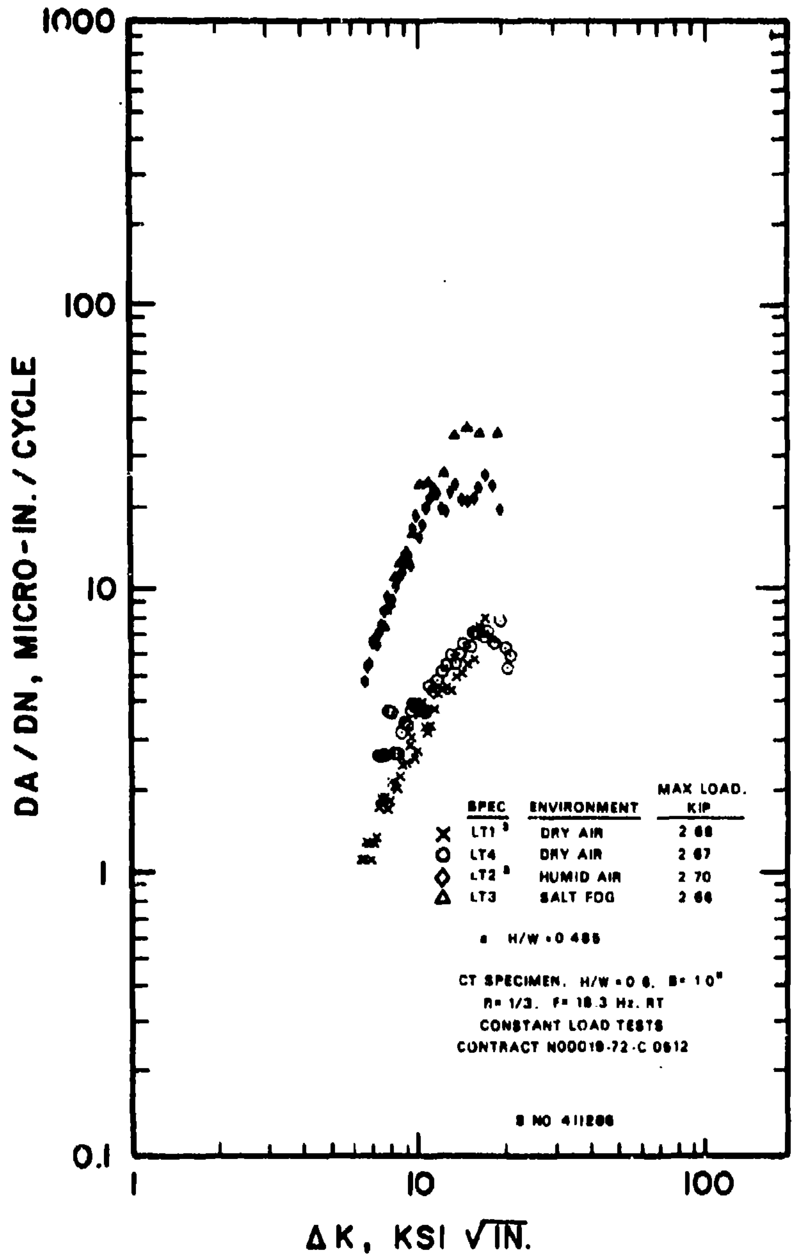


Fig. 159 **FATIGUE CRACK-GROWTH DATA FOR 5 x 6-1/4-IN. 7050-T76511 EXTRUSION L-T ORIENTATION**

Fig. 159

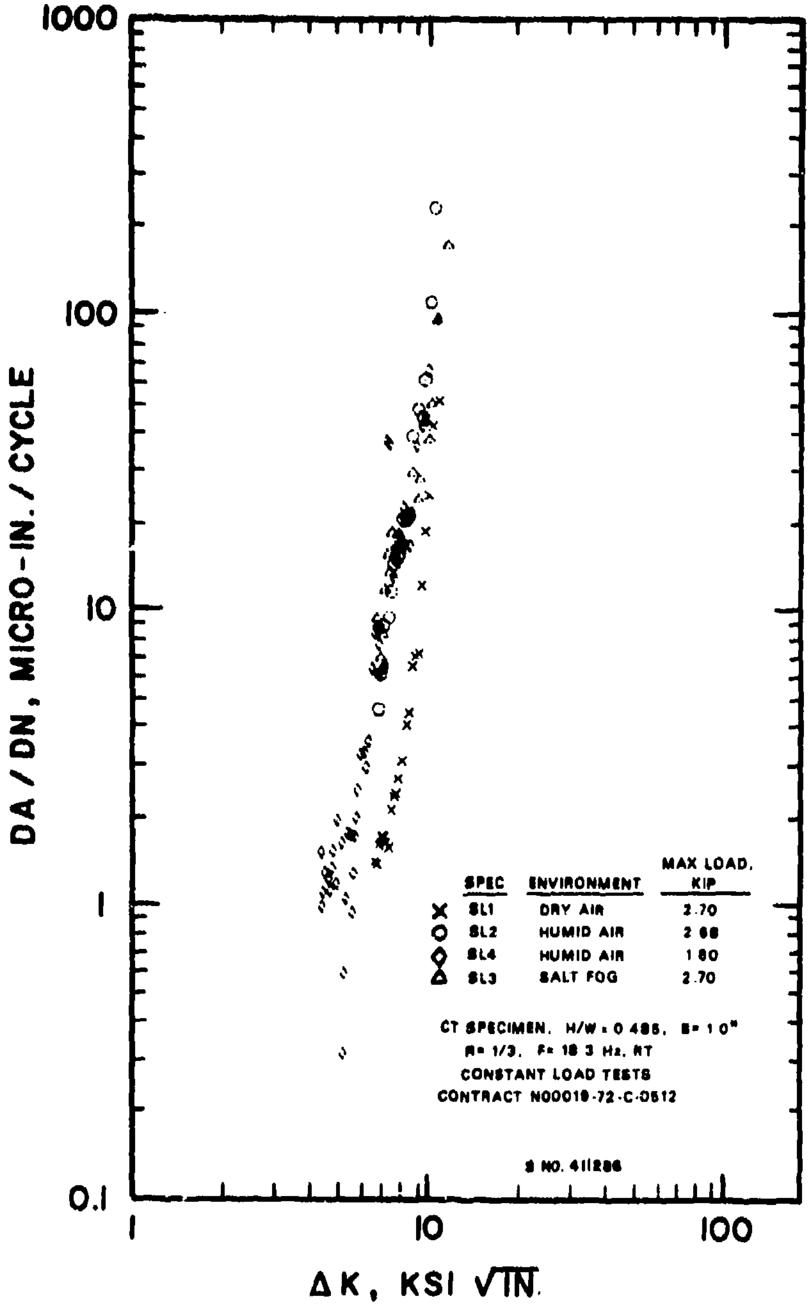
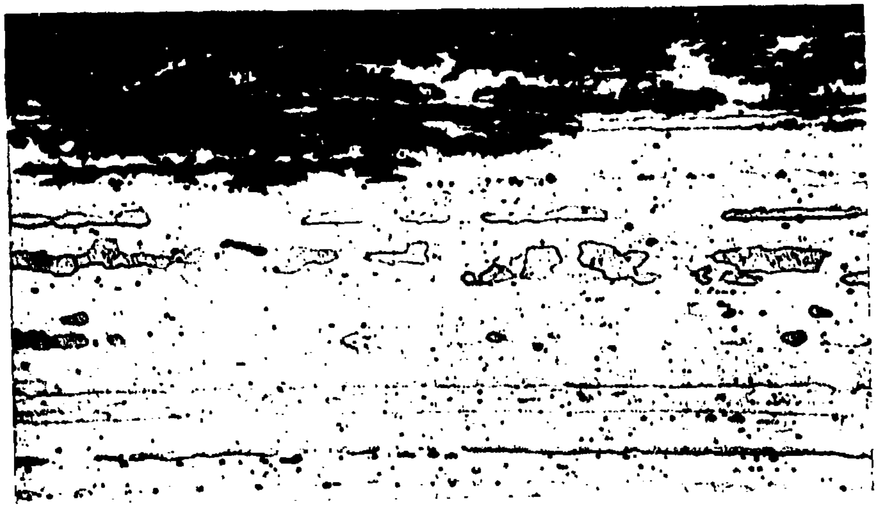


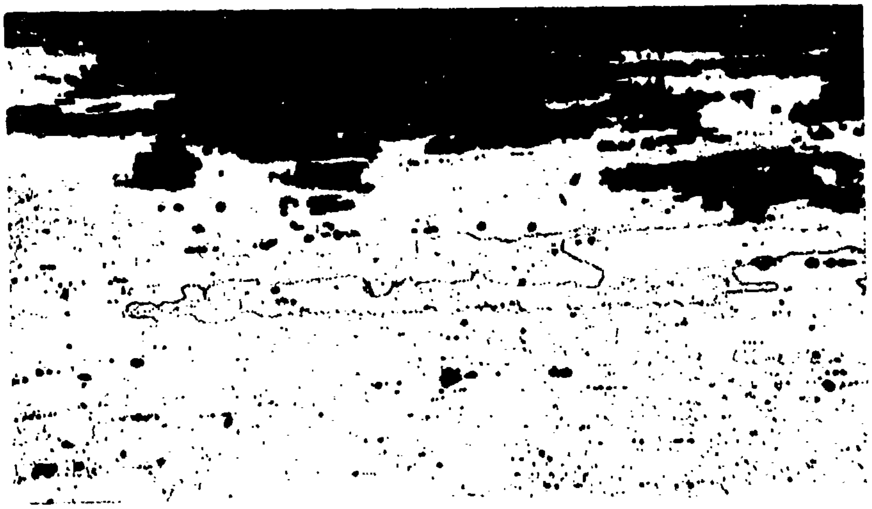
Fig. 160 **FATIGUE CRACK-GROWTH DATA FOR 5 x 6-1/4-IN. 7050-T76511 EXTRUSION S-L ORIENTATION**

Fig. 160



S. No. 411290-A Mag. 225X

Longitudinal Section at T/10 Plane of 0.665-in. Thick 7050-T76511 Extruded Section.

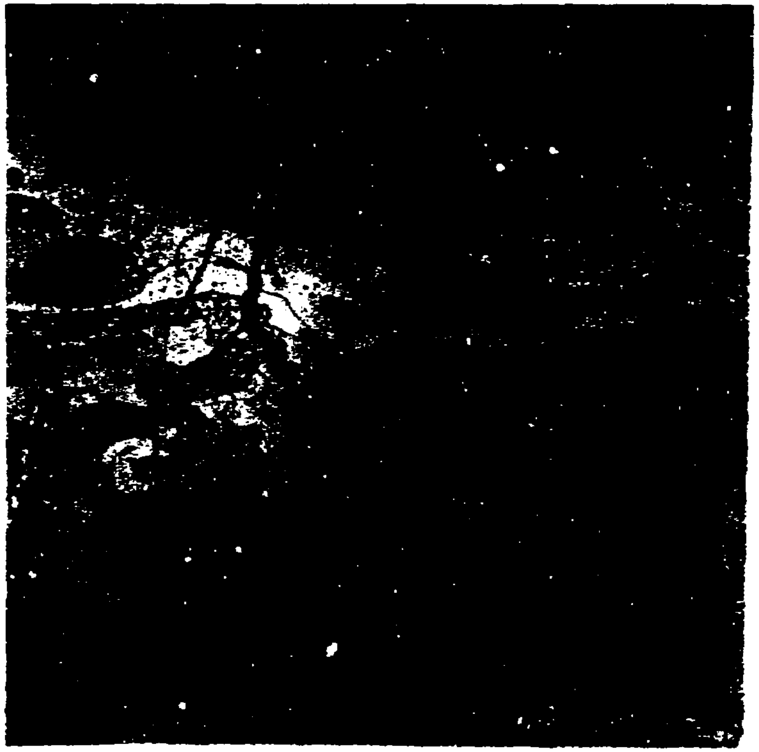


S. No. 411186-A Mag. 225X

Longitudinal Section at T/10 Plane of 2.00-in. Thick 7050-T73651 Plate

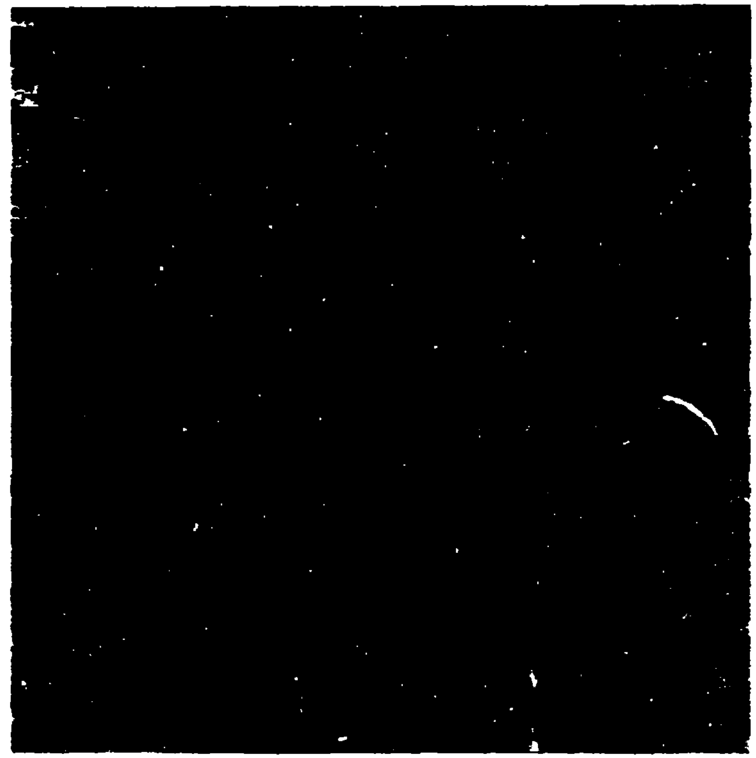
Fig. 161 Photomicrographs Illustrating Minor Exfoliation Attack in Alloy 7050 Products Exposed 48 Hours to "EXCO" Test. Note the corrosion is primarily an undermining pitting type of attack.

Fig. 161



S. No. 411187-L5 Mag. 100X

Longitudinal Specimen
Stressed 75% Y.S. - Failed 153 Days



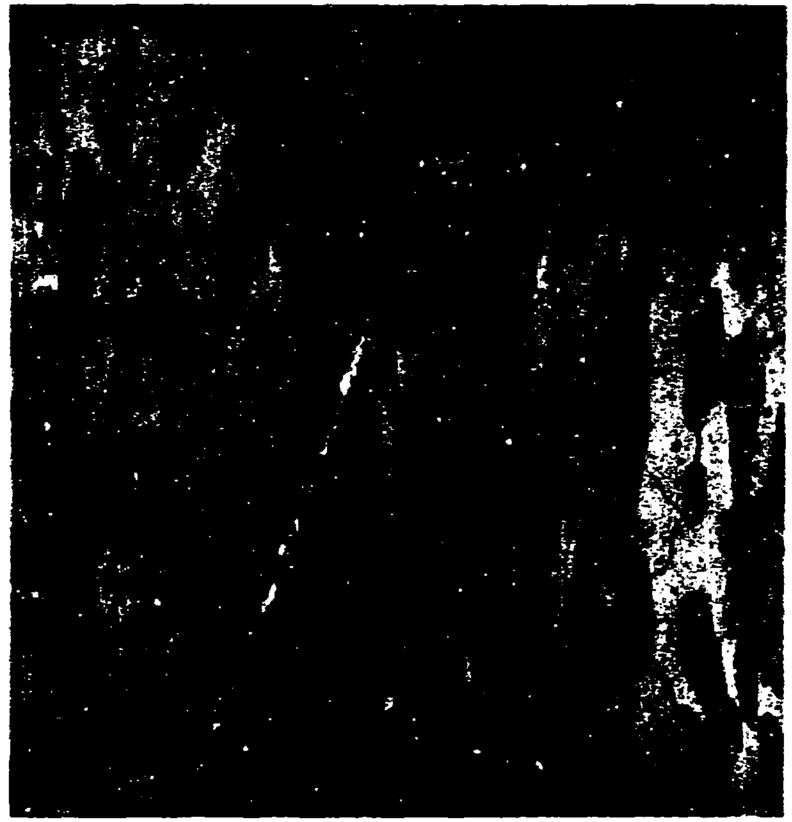
S. No. 411187-T3 Mag. 100X

Long-Transverse Specimen
Stressed 75% Y.S. - Failed 112 Days

Fig. 162 Photomicrographs Illustrating Severe Pitting and Auxiliary Transgranular Cracking in Longitudinal and Long-Transverse Specimens from 4" Thick 7050-T73651 Plate. Corrosion and Cracking are Typical of that Seen with All Plate Samples.

S. No. 410778-N5 Mag. 100X

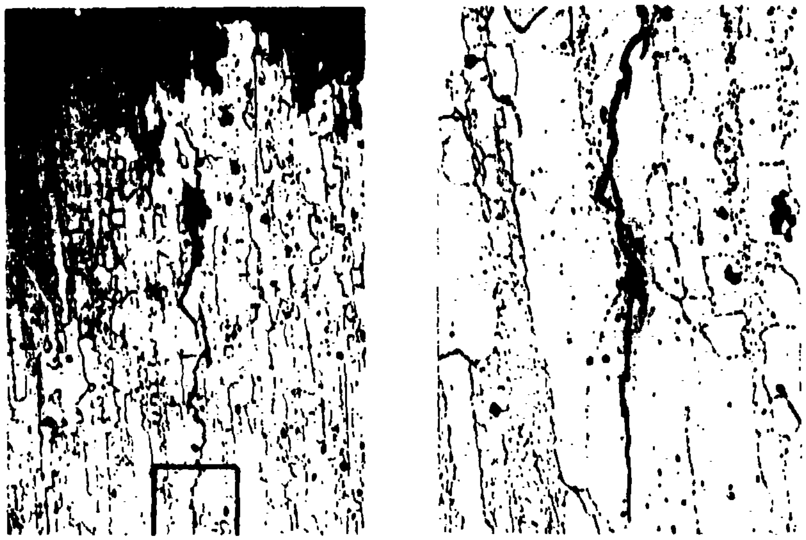
2-in. Thick
Stressed 45 ksi - Failed 76 Days



S. No. 411187-N4 Mag. 100X

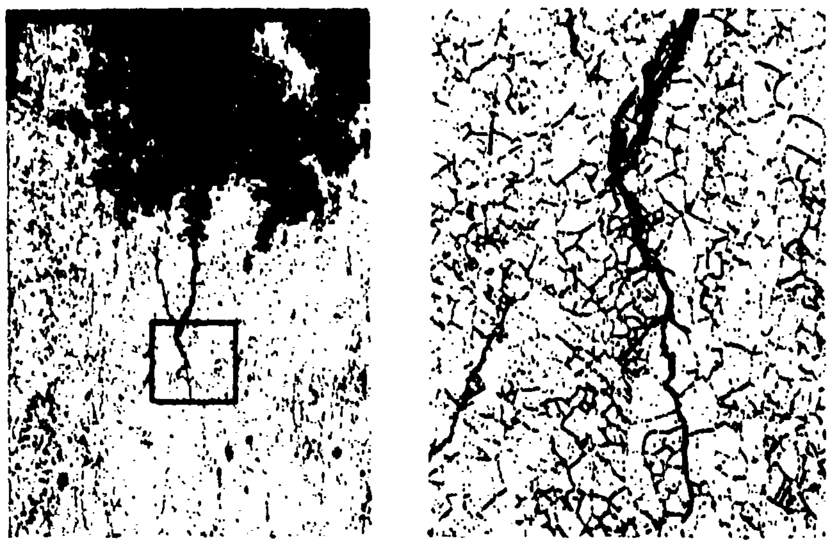
4-in. Thick
Stressed 45 ksi - Failed 73 Days

Fig. 163 Photomicrographs Illustrating the Mixed-Mode Nature of Auxiliary Cracking in Short-Transverse Specimens From 7050-T73651 Plate.



S. No. 411354-N5 Mag. 75X Mag. 400X

2 x 8-in. Forging, Stressed 45 ksi - Failed 82 Days



S. No. 411353-N5 Mag. 75X Mag. 400X

5.5 x 22-in. Forging, Stressed 45 ksi - Failed 71 Days

Fig. 164 Photomicrographs Illustrating the Predominantly Transgranular Nature of Auxiliary Cracking in Short-Transverse Specimens From 7050-T73652 Hand Forgings

S. No. 411332-N7 Mag.75X

Stressed 35 ksi - Failed 53 Days

S. No. 411233-N3 Mag. 75X

Stressed 45 ksi - Failed 42 Days

3.5% NaCl Alternate Immersion

S. No. 411332-N25 Mag. 75X
Stressed 45 ksi - Failed 139 Days
Seacoast Atmosphere

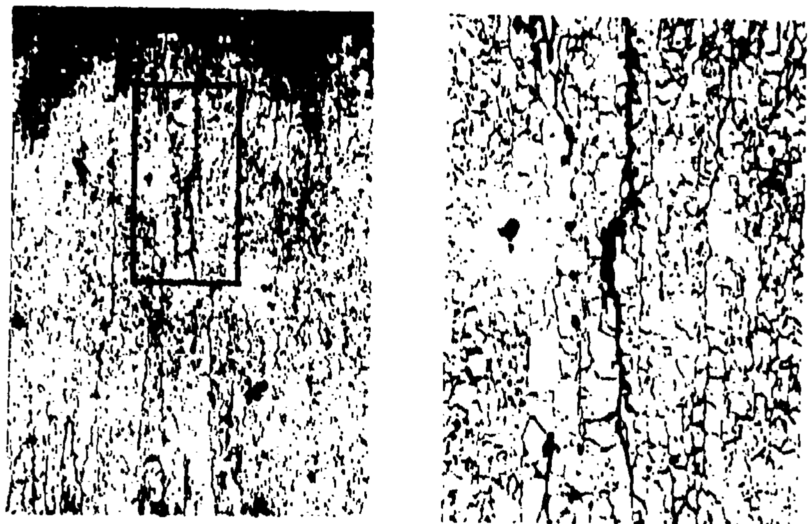
S. No. 411233-N15 Mag. 75X
Stressed 45 ksi - Failed 329 Days
Industrial Atmosphere

Fig. 165 Photomicrographs Illustrating the Predominantly Interfragmentary Nature of Auxiliary Cracking in Short-Transverse Specimens from 7050-T736 Die Forgings Exposed to Accelerated and Atmospheric Environments.

S. No. 411284-N11 **Mag. 75X**

Mag. 225X

1.5 x 7.5-in. Rectangle, Stressed 25 ksi - Failed 10 Days



S. No. 411285-N3 **Mag. 75X**

Mag. 225X

3.5 x 7.5-in. Rectangle, Stressed 45 ksi - Failed 12 Days

Fig. 166 Photomicrographs Illustrating the Interfragmentary Nature of Auxiliary Cracking in Short-Transverse Specimens from 7050-T76511 Extruded Shapes.

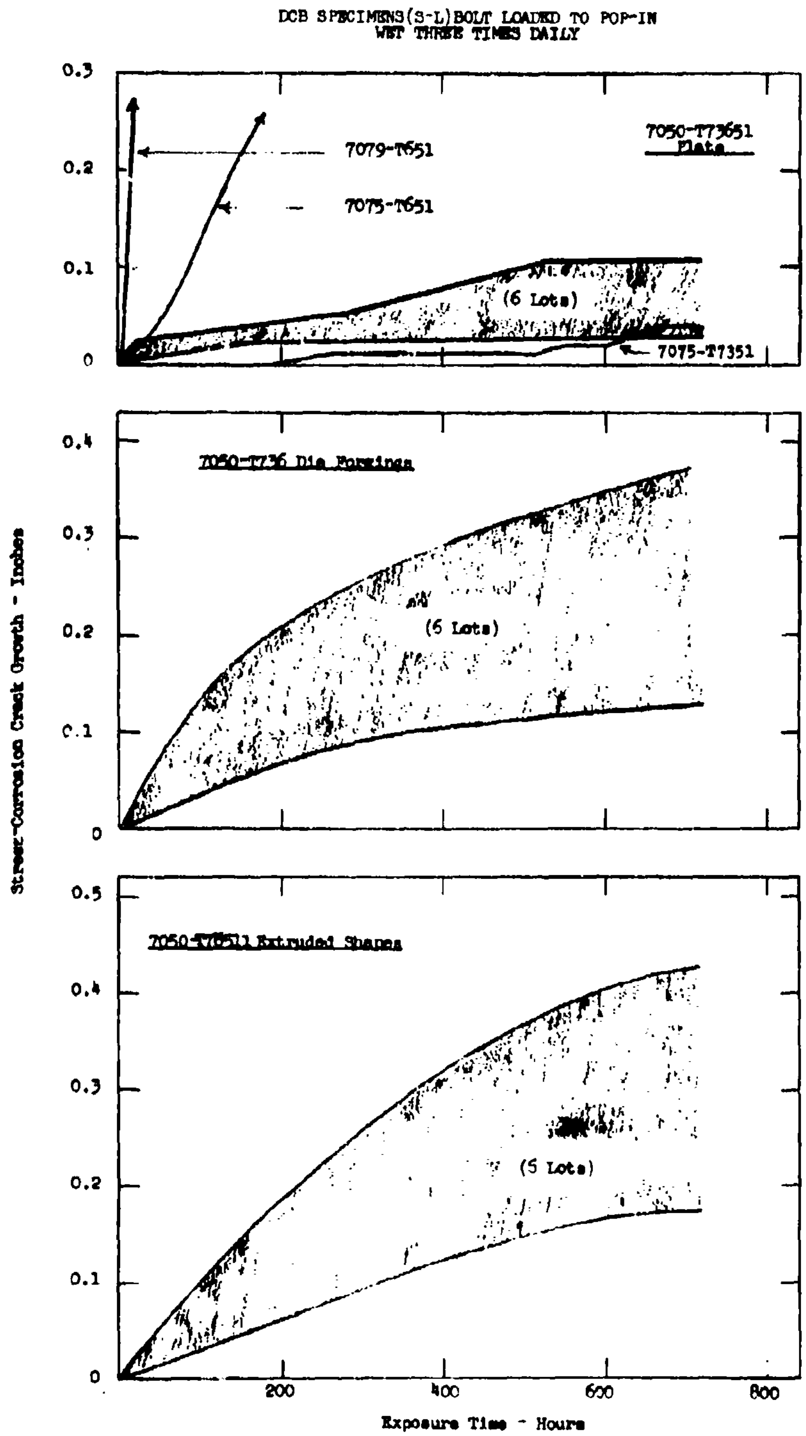
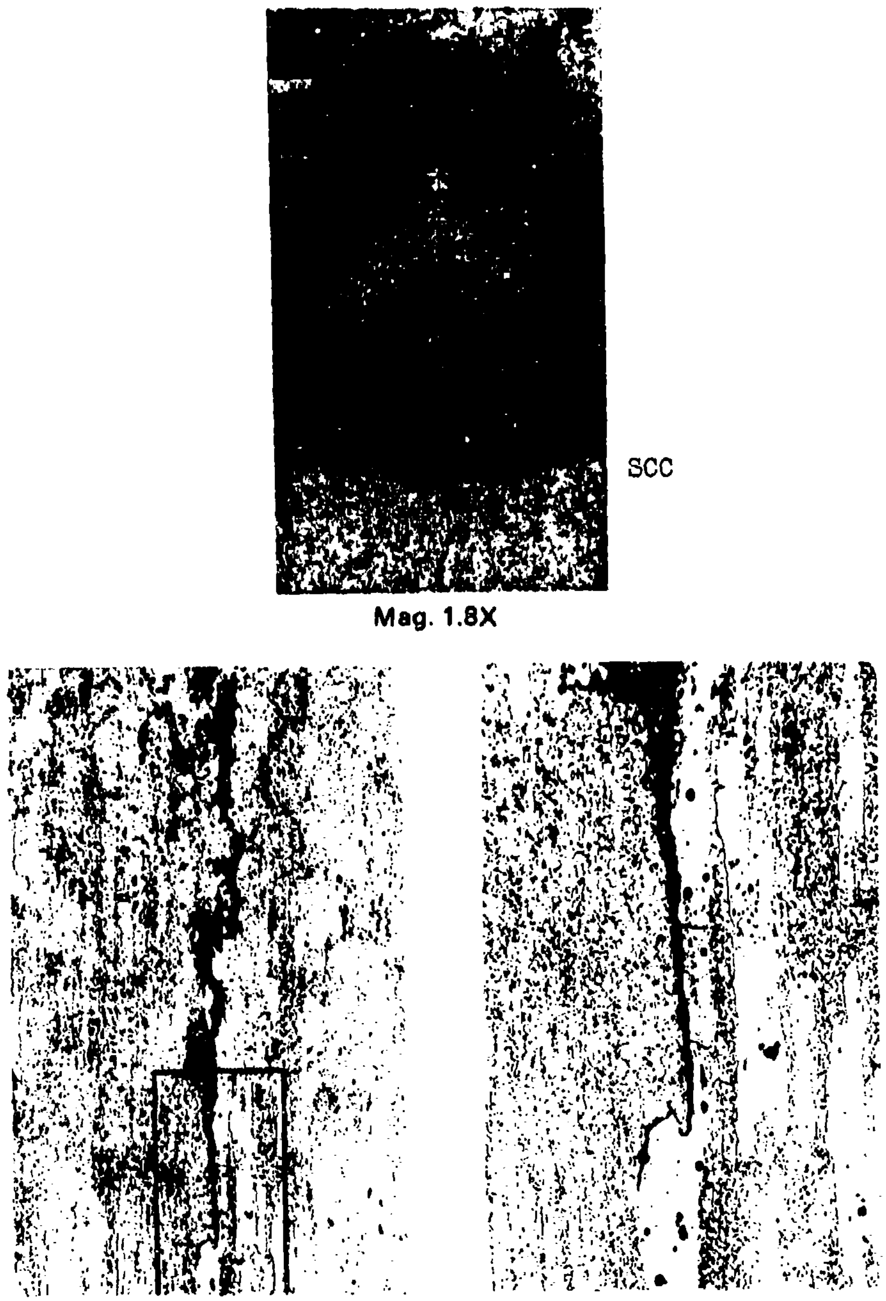


Fig. 167 Stress-Corrosion Crack Growth of Alloy 7050 Products in 3.5% NaCl

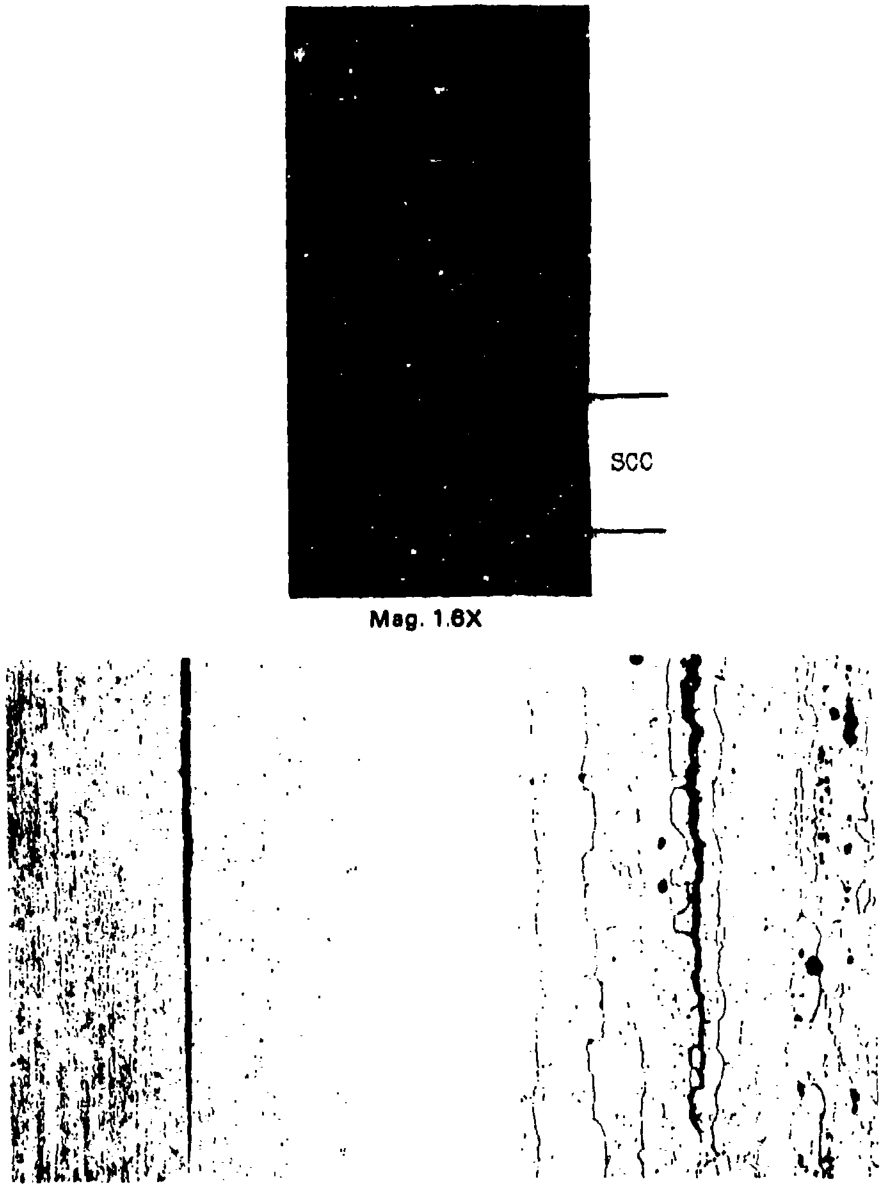
Fig. 167



Mag. 100X   Mag. 225X

S. No. 410778

Fig. 168 Illustrates Fracture Surface and Intergranular Nature of Cracking at the Tip of the Stress - Corrosion Crack in Short-Transverse (S-L) DCB Specimens from 2-in. Thick 7050-T73651 Plate.

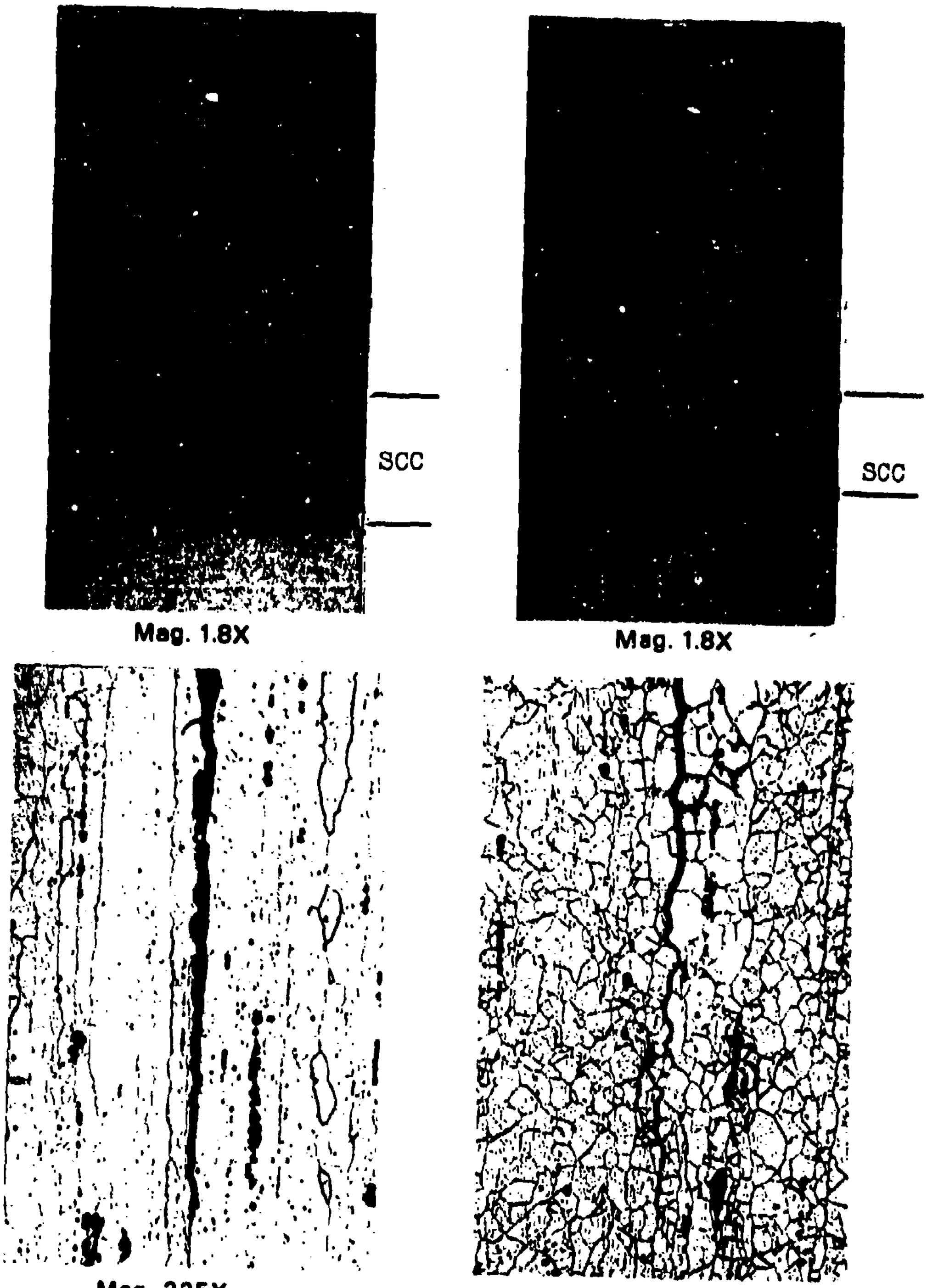


Mag. 7.5X Mag. 225X

S. No. 411233

Fig. 169 Illustrates Fracture Surface, Crack Profile and Interfragmentary Nature of Stress-Corrosion Crack Growth in Short-Transverse (S-L) DCB Specimens from 4.001 - 5.000-in. Thick 7050-T736 Die Forging.

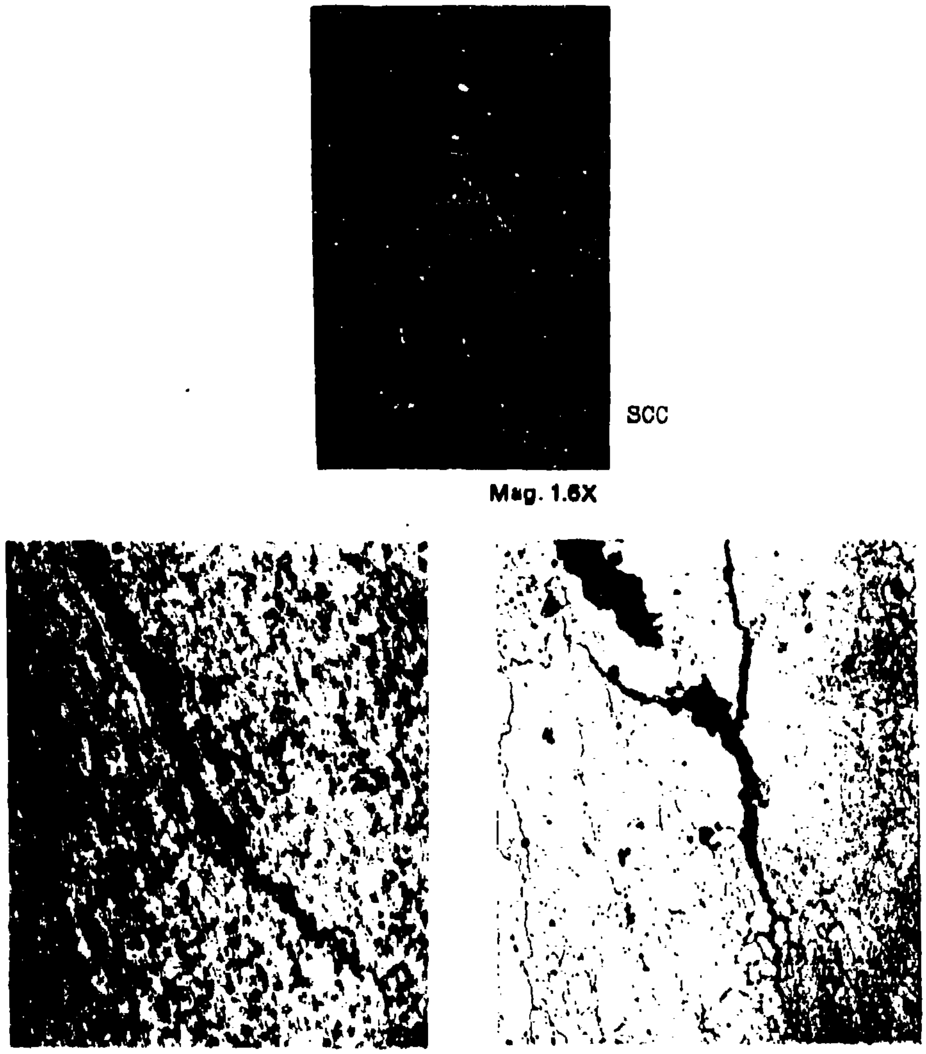
Fig. 169



Mag. 225X
S. No. 411287
1.161-in. Thick Section

Mag. 225X
S. No. 411286
5-in. Thick Section

Fig. 170 Illustrates Fracture Surfaces and Interfragmentary Nature of Stress-Corrosion Crack Growth in Short-Transverse (S-L) DCB Specimens from 7050-T76511 Extruded Shapes.



SCC

Mag. 1.6X

Mag. 75X

Mag. 225X

S. No. 411392

Fig. 171 Illustrates Fracture Surface, Crack Profile and Interfragmentary Nature of Stress-Corrosion Crack Growth in Short-Transverse (S-L) DCB Specimen from 2.001 - 4.000-in. Thick 7050-T736 Die Forging.

Fig. 171

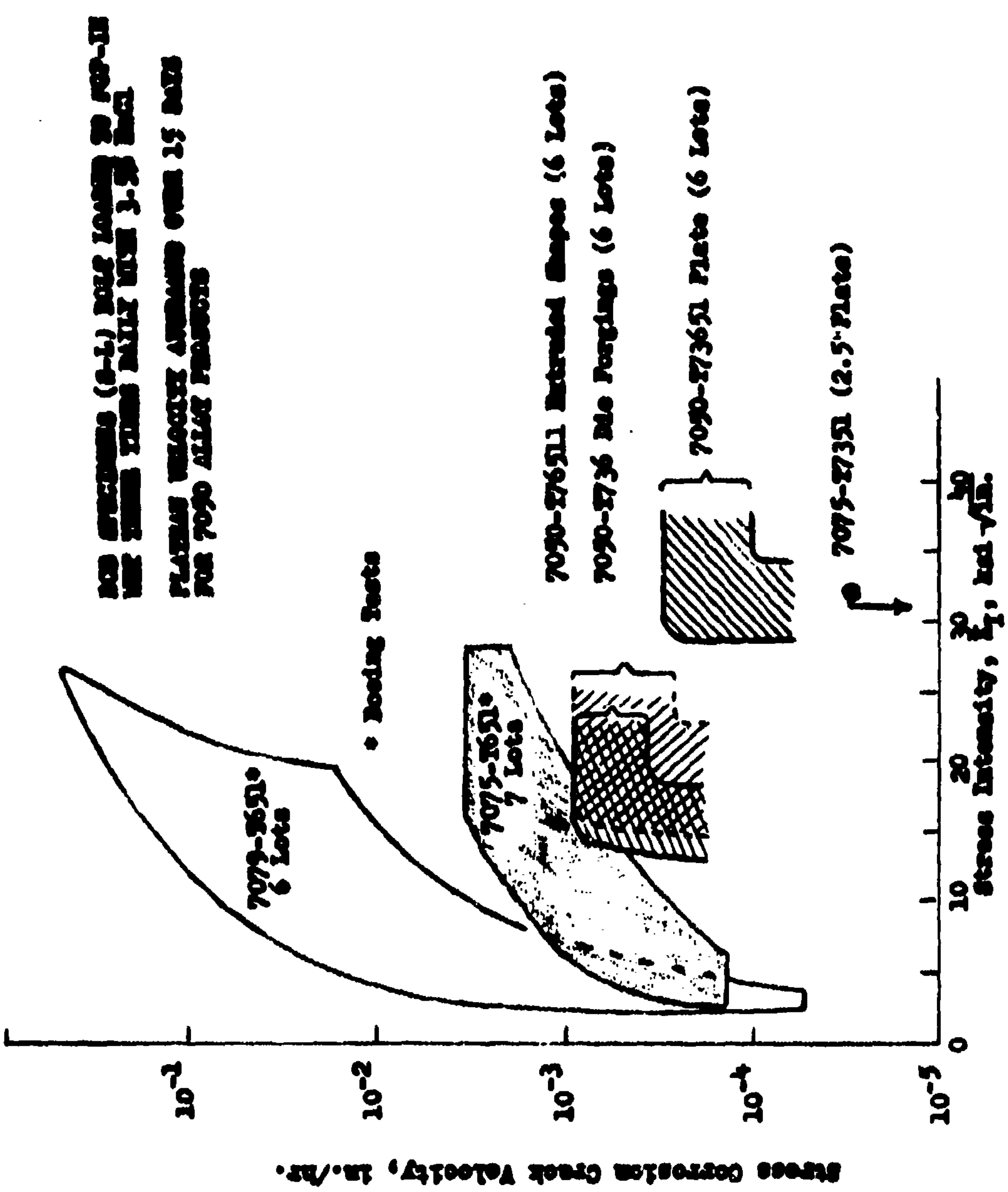


Fig. 172 K_I - Rate data for tests of alloy 7050 products.

Fig. 172

TABLE I

CHEMICAL COMPOSITIONS OF 7050-PRODUCTS

(NASC Contract No. N00019-72-C-0512)

Thickness or Size, in. (Die No.)	AL Sample No.	Element, per cent Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Zr
		7050-T76 Sheet									
0.040	428882	0.06	0.08	2.11	0.00	2.09	0.00	0.00	6.15	0.08	0.10
0.040	428985	0.06	0.10	2.05	0.01	2.14	0.01	0.00	6.05	0.08	0.10
0.063	411378	0.06	0.08	2.37	0.00	2.28	0.01	0.00	6.39	0.02	0.11
0.063	428884	0.08	0.08	2.15	0.00	2.13	0.00	0.00	5.94	0.08	0.10
0.090	411182	0.06	0.13	2.50	0.00	2.26	0.01	0.01	6.38	0.04	0.11
0.090	411183	0.07	0.11	2.26	0.01	2.25	0.02	0.01	6.19	0.04	0.11
0.125	411212	0.06	0.14	2.50	0.00	2.29	0.01	0.01	6.16	0.04	0.11
0.125	411213	0.07	0.12	2.25	0.01	2.30	0.02	0.01	6.27	0.04	0.10
0.187	413190	0.09	0.12	2.05	0.00	2.44	0.00	0.00	5.71	0.03	0.11
0.232	416020	0.06	0.08	2.57	0.01	2.27	0.01	0.00	6.46	0.02	0.10
0.249	411309	0.07	0.10	2.13	0.01	2.16	0.02	0.01	6.24	0.03	0.10
		7050-T73651 Plate									
0.500	411372	0.05	0.09	2.21	0.00	2.06	0.00	0.00	6.10	0.01	0.10
0.500	411184	0.06	0.10	2.26	0.00	2.32	0.01	0.01	6.54	0.02	0.10
1.000	411050	0.06	0.07	2.47	0.01	2.19	0.01	0.00	6.50	0.02	0.10
1.000	411185	0.06	0.15	2.57	0.00	2.30	0.01	0.01	6.35	0.04	0.11
2.000	410778	0.05	0.10	2.09	0.00	2.27	0.04	0.00	6.00	0.03	0.11
2.000	411186	0.06	0.10	2.19	0.00	2.26	0.01	0.01	6.27	0.02	0.10
4.000	410777	0.04	0.08	2.21	0.00	2.34	0.02	0.00	6.12	0.03	0.12
4.000	411187	0.06	0.11	2.13	0.01	2.22	0.02	0.01	6.29	0.03	0.10
6.000	411300	0.07	0.11	2.21	0.01	2.22	0.02	0.01	6.05	0.04	0.11
6.000	411330	0.07	0.11	2.32	0.01	2.27	0.01	0.00	6.19	0.04	0.10
		7050-T73652 Hand Forgings									
2x8x72*	411354	0.06	0.12	2.04	0.01	2.12	0.00	0.01	6.63	0.01	0.13
2-1/2x22x60	411229	0.05	0.12	2.29	0.00	2.29	0.00	0.00	6.22	0.01	0.10
3-1/2x22x84	411352	0.07	0.12	2.07	0.00	2.08	0.00	0.00	5.95	0.03	0.10
3-1/2x14x72*	428850	0.10	0.10	2.27	0.01	2.46	0.00	0.00	6.11	0.08	0.10
4-1/2x22x84	411250	0.05	0.11	2.21	0.00	2.32	0.00	0.00	6.13	0.03	0.10
4-1/2x22x84	411302	0.07	0.11	2.17	0.00	2.19	0.00	0.01	6.09	0.03	0.09
5-1/2x22x60	411353	0.07	0.12	2.09	0.00	2.09	0.00	0.00	5.90	0.03	0.10
5-1/2x22x45*	428851	0.10	0.10	2.26	0.01	2.44	0.00	0.00	6.02	0.02	0.10
7-1/2x22x42	411231	0.05	0.11	2.26	0.00	2.38	0.30	0.00	6.28	0.02	0.10
7-1/2x22x42	411232	0.07	0.12	2.21	0.01	2.23	0.00	0.00	6.21	0.02	0.10
		7050-T736 Die Forgings									
<1.000(2177)*	411243	0.08	0.13	2.47	0.01	2.53	0.03	0.01	6.53	0.02	0.12
<1.000(9078)	411331	0.05	0.10	2.10	0.00	2.28	0.00	0.00	6.10	0.02	0.09
1.001-2.000(15789)	411351	0.06	0.12	2.24	0.00	2.23	0.00	0.00	6.14	0.01	0.10
1.001-2.000(17975)	411281	0.06	0.13	2.24	0.00	2.25	0.00	0.01	6.11	0.02	0.10
1.001-2.000(17944)	411297	0.05	0.12	2.24	0.00	2.17	0.00	0.00	5.96	0.01	0.10
2.001-4.000(1364)*	411392	0.06	0.12	2.09	0.01	2.16	0.00	0.01	6.49	0.01	0.12
3.001-4.000(8457)	411332	0.06	0.10	2.18	0.00	2.40	0.00	0.00	6.31	0.02	0.10
4.001-5.000(4736)*	411244	0.08	0.12	2.43	0.01	2.53	0.03	0.01	6.40	0.02	0.12
4.001-5.000(12767)	411233	0.06	0.12	2.29	0.00	2.30	0.00	0.01	6.26	0.01	0.10
6.000-7.000(16392)	411303	0.05	0.11	2.24	0.00	2.36	0.00	0.01	6.18	0.02	0.09
		7050-T76511 Extruded Shapes									
0.187(86366)	411288	0.05	0.10	2.16	0.00	2.37	0.00	0.01	6.32	0.02	0.09
0.402(191282)	411289	0.05	0.10	2.18	0.00	2.38	0.00	0.00	6.23	0.02	0.09
0.665(213592)	411290	0.07	0.10	2.29	0.01	2.17	0.00	0.00	5.98	0.02	0.10
0.841(53717)*	411552	0.10	0.10	2.28	0.01	2.51	0.00	0.00	6.17	0.02	0.10
1.161(231372)	411287	0.07	0.11	2.34	0.01	2.28	0.00	0.01	6.20	0.02	0.10
1-1/2x7-1/2	411284	0.05	0.11	2.21	0.00	2.42	0.00	0.00	6.28	0.02	0.09
2x8*	411279	0.08	0.15	2.00	0.03	1.96	0.03	0.01	6.53	0.00	0.13
3-1/2x7-1/2	411285	0.06	0.11	2.20	0.00	2.45	0.00	0.01	6.48	0.02	0.09
4x8*	411280	0.08	0.15	2.07	0.04	1.95	0.02	0.01	6.62	0.00	0.13
5x6-1/4	411286	0.06	0.11	2.20	0.00	2.46	0.00	0.01	6.49	0.02	0.09
Composition Limits†‡		0.12	0.15	2.0-2.6	0.10	1.9-2.6	0.04	--	5.7-6.7	0.06	0.08-0.15
Nominal Composition‡		--	--	2.3	--	2.25	--	--	6.2	--	0.12

* Producer B, all others Producer A.
† Maximum unless A range is shown.
‡ Registration Record of Aluminum Association Alloy Designations and Chemical Composition Limits of Wrought Aluminum Alloys, May 1, 1973.

TABLE II

MECHANICAL PROPERTIES OF 7050-T76 SHEET

(NASC Contract No. N00019-72-C-0512)

Sample Thickness, in.	Sample Number	Specimen Direction†	Tensile Strength, ksi	Tensile Yield Strength,* ksi	Elong in 2 in., or 4D, %	Compressive Yield Strength,* ksi	Shear Strength, ksi	Bearing Strength,§ ksi e/D=1.5	Bearing Strength,§ ksi e/D=2.0	Bearing Yield Strength,§ ksi e/D=1.5	Bearing Yield Strength,§ ksi e/D=2.0
								(Flatwise Specimens)			
0.040	428882	L	79.6	73.2	10.0	71.2	49.0‡	124.6	158.7	101.9	114.9
		LT	81.6	73.5	10.0	76.0		126.2	155.2	100.0	120.6
0.040	428985	L	79.7	73.4	9.0	73.5	49.6‡	122.6	162.7	101.8	117.8
		LT	81.0	73.1	9.0	78.4		123.2	156.7	101.8	115.7
0.063	411378	L	83.0	77.7	10.5	77.1	50.4‡	126.0	165.9	102.9	120.8
		LT	84.3	78.2	10.0	82.2		126.9	167.9	103.2	119.5
0.063	428884	L	79.2	73.3	10.5	73.9	47.9‡	125.0	162.2	103.8	121.9
		LT	80.6	73.0	10.5	77.3		125.0	162.5	101.2	121.9
0.090	411182	L	84.5	78.9	11.0	78.9	51.2‡	133.3	173.4	112.1	127.6
		LT	83.9	77.0	11.0	83.6		133.3	172.9	113.6	133.7
0.090	411183	L	83.8	78.3	11.0	78.9	50.0‡	131.3	168.8	111.2	125.0
		LT	82.4	75.5	11.0	81.0		129.4	171.0	110.5	129.5
0.125	411212	L	83.6	79.6	11.0	79.3	49.7‡	131.5	169.1	110.7	121.5
		LT	83.7	77.9	11.5	83.4		130.7	170.0	111.2	127.0
0.125	411213	L	83.1	78.7	11.0	77.8	50.2‡	130.3	169.0	109.4	122.8
		LT	83.0	77.2	11.5	82.6		131.1	168.7	112.5	125.2
0.13[illegible]	413150	L	81.1	75.0	11.0	75.8	49.8‡	131.4	169.0	112.2	129.2
		LT	83.3	74.5	11.5	80.4		132.4	159.0	113.5	132.2
0.222	415020	L	83.4	76.6	11.0	81.3	54.0 49.7‡	134.0	170.6	117.3	125.9
		LT	84.5	76.3	11.0	84.1	53.2	129.1	171.0	111.9	130.9
0.249	411309	L	83.2	80.2	12.5	80.3	49.7 49.8‡	132.9	159.4	111.3	124.1
		LT	83.5	78.4	13.0	84.0	51.9	132.0	159.1	111.[illegible]	127.2
			Tentative Minimum Properties								
0.040–0.249		L	78	71	8	—	—	—	—	—	—
		LT	78	69	8	—	—	—	—	—	—

* Offset equals 0.2 per cent.
† L - Longitudinal; LT - Long-Transverse
‡ Punch-type sheet shear specimens; L and LT shear strengths for 0.222 and 0.249-in. sheet are from tests of cylindrical specimens made in an Amsler double-shear tool.
§ Specimens cleaned ultrasonically; yield strength offset equals 2 per cent of pin diameter.

TABLE III

MECHANICAL PROPERTIES OF 7050-T73651 PLATE
(NASC Contract No. N00019-72-C-0512)

Sample Thickness, in.	Sample Number	Specimen Location†	Specimen Direction‡	Tensile Strength, ksi	Tensile Yield Strength,* ksi	Elong in 2 in., or 4D, %	Compressive Yield Strength,* ksi	Shear Strength, ksi	Bearing Strength,§ ksi e/D=1.5	Bearing Strength,§ ksi e/D=2.0	Bearing Yield Strength,§ ksi e/D=1.5	Bearing Yield Strength,§ ksi e/D=2.0
									(Flatwise Specimens)			
0.500	411372	T/2	L	75.9	66.1	15.7	65.3	45.0	109.9	145.3	89.2	107.6
		T/2	LT	75.3	65.7	15.7	67.9	43.6	111.6	145.0	90.6	109.2
0.500	411184	T/2	L	76.3	66.9	15.0	66.2	45.0	115.4	145.9	93.4	111.1
		T/2	LT	76.5	67.2	14.3	69.8	44.7	114.2	148.3	91.9	111.0
1.000	411185	T/2	L	74.9	65.4	13.0	64.7	44.2	114.1	144.2	93.1	106.8
		T/2	LT	75.1	65.4	12.0	68.5	43.5	113.5	148.2	92.7	112.0
1.000	411050	T/2	L	79.9	70.8	13.5	71.1	45.5	112.1	151.1	94.7	110.3
		T/2	LT	79.0	70.0	12.0	73.1	45.3	118.0	150.6	96.2	112.4
2.000	411186	T/4	L	75.3	65.9	12.5	64.7	46.5	116.4	150.4	95.5	111.3
		T/4	LT	75.5	65.7	11.0	68.9	46.5	117.4	153.6	97.6	116.6
		T/2	ST	72.9	61.5	7.8	68.2	44.7	—	—	—	—
2.000	410778	T/4	L	75.2	65.7	13.0	64.4	46.7	116.8	149.2	96.6	108.4
		T/4	LT	75.9	65.5	11.5	69.3	46.1	115.9	148.9	98.2	111.0
		T/2	ST	70.9	62.2	4.9	66.2	44.6	—	—	—	—
4.000	410777	T/4	L	74.0	65.3	12.0	61.9	46.9	116.5	147.6	98.0	109.9
		T/4	LT	75.6	64.4	11.0	68.0	46.7	115.3	149.6	97.5	111.7
		T/2	ST	72.9	60.9	6.4	68.3	43.6	—	—	—	—
4.000	411187	T/4	L	72.0	63.7	11.0	61.4	45.5	115.1	147.2	95.0	110.1
		T/4	LT	73.3	63.2	10.0	67.0	45.0	114.2	147.5	94.7	112.3
		T/2	ST	69.9	59.7	7.1	65.2	41.9	—	—	—	—
6.000	411300	T/4	L	69.7	60.9	9.5	58.0	45.2	107.7	139.0	92.2	108.0
		T/4	LT	70.5	59.1	7.5	63.1	45.1	110.3	142.2	92.9	109.0
		T/2	ST	67.7	56.8	5.0	63.0	42.3	—	—	—	—
6.000	411330	T/4	L	73.0	64.3	9.0	60.2	46.9	112.6	144.7	97.1	112.4
		T/4	LT	72.2	62.1	6.0	66.7	46.3	114.0	147.5	96.6	114.6
		T/2	ST	68.7	59.3	3.5	66.5	42.5	—	—	—	—
						Minimum Properties						
0.250–2.000			L	71	63	9	—	—	—	—	—	—
			LT	72	63	6	—	—	—	—	—	—
3.001–4.000			L	69	60	9	—	—	—	—	—	—
			LT	70	60	6	—	—	—	—	—	—
			ST	66	56	2	—	—	—	—	—	—
5.001–6.000			L	66	56	8	—	—	—	—	—	—
			LT	67	56	5	—	—	—	—	—	—
			ST	63	53	2	—	—	—	—	—	—

* Offset equals 0.2 per cent.
† T - Thickness; T/4 - Midway between center and surface; T/2 - Center
‡ L - Longitudinal; LT - Long-Transverse, ST - Short-Transverse
§ Specimens cleaned ultrasonically; yield strength-offset equals 2 per cent of pin diameter.

TABLE IV

MECHANICAL PROPERTIES OF 7050-T73652 HAND FORGINGS

(NASC Contract No. N00019-[illegible]-C-0512)

Sample Size, in.	Sample Number	Specimen Direction,‡	Tensile Strength, ksi	Tensile Yield Strength,† ksi	Elong. in 4 D, %	Compressive Yield Strength,† ksi	Shear Strength, ksi	Bearing Strength,* ksi e/D=1.5 (Pin-type Specimens)	Bearing Strength,* ksi e/D=2.0	Bearing Yield Strength,* ksi e/D=1.5	Bearing Yield Strength,* ksi e/D=2.0
[illegible]**	411358	L LT ST	72.3 [illegible] 70.7	72.6 72.3 67.6	8.5 6.5 4.7	77.0 76.4 75.2	48.2 47.0 47.5	111.4 116.5 --	154.2 156.2 --	88.1 100.3 --	120.0 126.1 --
2-1/[illegible]x60	411289	L LT ST	75.7 [illegible] 74.3	67.3 [illegible] 61.3	10.5 13.0 10.0	67.2 [illegible] [illegible]	43.5 [illegible] [illegible]	105.0 113.8 --	130.0 105.4 --	[illegible] [illegible] --	111.8 113.9 --
3-1/2x14x72**	408850	L LT ST	71.6†† 70.1†† 67.9‡‡	61.1†† 60.8†† 54.5‡‡	13.2†† 8.8†† 4.3‡‡	64.9 65.1 63.7	40.3 43.0 40.1	100.0 99.4 --	136.8 130.1 --	91.8 91.0 --	107.0 106.7 --
3-1/[illegible]x84	411352	L LT ST	77.6 75.5 73.5	70.0 68.0 66.4	11.5 10.0 6.4	72.3 73.5 73.8	46.3 47.5 40.8	98.4 104.5 --	136.0 160.0 --	91.0 [illegible] --	106.4 107.5 --
4-1/[illegible]x84	411850	L LT ST	72.0 [illegible] 69.8	60.1 [illegible] 57.3	13.2 7.2 7.9	61.6 [illegible] [illegible]	40.3 41.8 41.3	90.6 102.9 --	133.7 [illegible] --	[illegible] 87.6 --	100.9 [illegible] --
4-1/[illegible]x84	411302	L LT ST	72.8 70.1 71.5	63.8 [illegible] 61.1	11.5 10.5 7.1	[illegible] 67.6 65.0	43.3 [illegible] 41.7	99.4 105.4 --	136.2 134.8 --	[illegible] [illegible] --	107.8 [illegible] --
5-1/[illegible]x60**	408851	L LT ST	69.8# 68.8 67.3	60.0# 62.6 57.1	14.0# 6.0 3.5	63.2 61.4 60.6	40.3 38.1 40.5	104.0 101.2 --	130.2 134.2 --	[illegible] [illegible] --	108.9 107.6 --
5-1/[illegible]x60	411353	L LT ST	76.8 [illegible] 73.4	[illegible] [illegible] 68.1	11.0 9.0 8.0	70.0 78.1 70.0	[illegible] [illegible] 43.8	102.3 106.5 --	138.2 [illegible] --	88.0 [illegible] --	107.4 113.7 --
7-1/[illegible]x42	411851	L LT ST	71.0 70.9 69.5	60.0 [illegible] 57.8	13.0 [illegible] 5.0	[illegible] [illegible] [illegible]	44.4 [illegible] 40.5	108.0 100.7 --	136.0 [illegible] --	[illegible] [illegible] --	[illegible] 97.3 --
7-1/[illegible]x42	411852	L LT ST	72.4 71.0 71.0	[illegible] [illegible] 58.1	13.5 [illegible] 6.0	[illegible] [illegible] [illegible]	46.4 43.0 40.8	108.4 103.7 --	134.8 136.8 --	[illegible] [illegible] --	101.4 [illegible] --
						Minimum Properties					
Up to 2.000		L LT	72 71	[illegible] [illegible]	9 5	-- --	-- --	-- --	-- --	-- --	-- --
2.001-3.000		L LT ST	72 70 67	[illegible] [illegible] [illegible]	9 [illegible] 4	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --
3.001-4.000		L LT ST	71 70 67	[illegible] [illegible] 55	9 [illegible] 3	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --
4.001-5.000		L LT ST	70 [illegible] [illegible]	[illegible] [illegible] [illegible]	9 [illegible] 3	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --
5.001-6.000		L LT ST	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]	[illegible] [illegible] 3	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --
7.001-8.000		L LT ST	[illegible] [illegible] [illegible]	57 [illegible] 55	9 [illegible] 3	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --

† Offset equals 0.2 per cent.
‡ Specimens located within center third of thickness and width.
L = Longitudinal; LT = Long-Transverse; ST = Short-Transverse.
* Specimens clamped [illegible]; yield strength - offset equals 2 per cent of pin diameter.
** Producer B, all others Producer A.
†† Average of two retests; tensile strength from initial test below minimum value (69.9 ksi).
‡‡ Average of two retests; equipment malfunctioned in initial test. One of the tensile strengths from retests below minimal value (68.9 and 69.6 ksi).
# Average of two retests; tensile and yield strengths of initial tests below minimum values.

TABLE V

MECHANICAL PROPERTIES OF 7050-T736 DIE FORGINGS
(NASC Contract No. N00019-72-C-0512)

Approximate Thickness in.	Sample Number	Die No.	Specimen Direction†	Tensile Strength, ksi	Tensile Yield Strength,* ksi	Elong in 2 in. or 4D, %	Compressive Yield Strength,* ksi	Shear Strength, ksi	Bearing Strength,‡ ksi e/D=1.5	Bearing Strength,‡ ksi e/D=2.0	Bearing Yield Strength,‡ ksi e/D=1.5	Bearing Yield Strength,‡ ksi e/D=2.0
									(Edgewise Specimens)			
0.6**	411243	2177	L	82.2	75.4	13.6	76.9	45.6	113.6	148.8	96.6	112.3
			ST	73.8	64.5	8.0	68.1	47.4	—	—	—	—
0.7	411331	9078	L	79.9	72.9	13.6	75.1	45.4	112.1	141.8	92.4	110.2
			ST	73.1	63.5	9.0	67.5	45.4	—	—	—	—
1.1	411351	15789	L	76.0	69.1	8.5	72.0	47.9	113.9	148.6	97.7	113.0
			ST	75.2	68.1	7.5	70.7	47.0	—	—	—	—
1.25	411281	17975	L	75.6	68.0	14.0	71.3	48.0	113.4	150.7	101.4	120.5
			ST	75.3	66.7	7.0	70.8	44.5	—	—	—	—
1.95	411297	17944	L	76.7	68.8	15.5	76.1	49.8	118.4	148.9	101.1	115.8
			ST	74.5	67.0	6.5	71.0	48.2	—	—	—	—
3.1**	411392	1364	L	73.7	64.7	14.0	69.4	43.6	97.7	134.2	84.7	101.9
			ST	65.6††	58.9	3.5††	63.8	41.3	—	—	—	—
3.5	411332B	8457	L	77.4	70.2	12.0	74.3	45.6	105.0	140.4	92.0	111.9
			ST	75.7	68.3	7.1	71.9	40.6	—	—	—	—
4.02 dia.**	411244	4736	L	77.4	69.0	12.0	73.1	44.3	101.7	136.0	89.0	104.8
			ST	71.3	63.6	5.0	66.7	43.6	—	—	—	—
4.25 dia.	411233	12767	L	75.6	69.3	14.0	72.3	48.3	117.7	154.2	103.9	115.3
			ST	74.4	66.5	7.1	69.5	45.7	—	—	—	—
5.5	411332A	8457	L	76.6	68.5	11.0	72.8	46.8	107.4	139.5	91.2	104.8
			ST	74.0	68.5	6.0	68.7	44.5	—	—	—	—
6.1	411303	16392	L	72.3	63.2	8.5	70.7	48.1	104.8	137.4	99.0	117.1
			ST	72.9	65.7	4.0	67.1	44.2	—	—	—	—
							Minimum Properties					
Up to 2.000			L	72	62	7	--	--	--	--	--	--
			ST	68	56	5	--	--	--	--	--	--
2.001-4.000			L	71	61	7	--	--	--	--	--	--
			ST	67	55	4	--	--	--	--	--	--
4.001-5.000			L	70	60	7	--	--	--	--	--	--
			ST	66	54	5	--	--	--	--	--	--
5.001-6.000			L	70	59	7	--	--	--	--	--	--
			ST	66	54	5	--	--	--	--	--	--

* Offset equals 0.2 per cent.
† L-Longitudinal, ST-Short-Transverse
‡ Specimens cleaned ultrasonically; yield strength - offset equals 2 per cent of pin diameter.
** Producer B, all others Producer A.
†† Below tentative minimum properties; average results of three tests.

TABLE VI

MECHANICAL PROPERTIES OF 7050-T76511 EXTRUDED SHAPES
(NAVSEC Contract No. N00019-72-C-0512)

Sample Thickness or Size, in.	Sample Number	Die No.	Specimen Location†	Specimen Direction‡	Tensile Strength, ksi	Tensile Yield Strength,* ksi	Elong in 2 in., in 4D, %	Compressive Yield Strength,* ksi	Shear Strength, ksi	Bearing Strength,§ ksi e/D=1.5	Bearing Strength,§ ksi e/D=2.0	Bearing Yield Strength,§ ksi e/D=1.5	Bearing Yield Strength,§ ksi e/D=2.0
										(Flatwise Specimens)			
0.187	411288	86366	W/4	L	85.1	75.9	10.0	81.9	47.8	122.1	159.0	101.9	121.5
			W/2	LT	85.4	76.9	10.0	78.9	45.9	125.2	160.2	102.7	121.9
0.402	411289	191382	W/4	L	83.8	75.6	14.0	78.2	49.4	128.8	164.2	109.7	128.3
			W/2	LT	83.4	73.0	10.0	81.3	49.6	131.2	167.6	112.[illegible]	135.7
0.665	411290	213592	T/2,W/4	L	85.4	78.2	14.3	78.8	46.9	126.7	162.4	108.7	129.9
			T/2,W/2	LT	84.1	76.9	12.9	80.0	46.8	127.7	165.2	108.7	130.7
0.841**	411552	52717	T/2,W/2	L	82.8	75.2	11.0	79.1	47.1	121.9	160.2	104.4	122.2
				LT	81.6	74.1	11.0	76.0	45.1	124.7	159.1	105.1	122.2
1.161	411287	251372	T/2,W/4	L	85.6	76.4	12.0	76.9	49.6	127.9	162.7	109.0	124.3
			T/2,W/2	LT	82.5	74.4	11.0	79.2	48.7	126.3	165.2	107.5	132.4
1.5x7.5	411284	††	T/2,W/4	L	85.0	78.4	13.0	80.5	48.5	126.9	162.6	105.9	120.0
			T/2,W/2	LT	82.0	75.3	12.0	79.9	48.3	126.5	164.3	105.4	124.6
			T/2,W/2	ST	82.3	69.8	8.0	82.2	—	—	—	—	—
2.0x6.0**	411279	††	T/4,W/4	L	81.6	75.6	13.0	76.5	45.8	120.9	156.9	101.3	115.5
			T/2,W/2	LT	76.9	71.0	10.0	75.3	44.4	119.2	154.2	101.9	115.1
			T/2,W/2	ST	76.0	66.7	6.0	75.7	40.8	—	—	—	—
3.5x7.5	411285	††	T/4,W/4	L	86.6	80.5	11.0	82.1	48.2	124.9	158.6	104.0	119.1
			T/2,W/2	LT	80.3	74.1	7.0	79.0	47.0	121.5	156.9	102.2	121.4
			T/2,W/2	ST	79.9	70.9	2.9	76.9	43.6	—	—	—	—
4.0x6.0**	411280	††	T/4,W/4	L	84.6	79.[illegible]	11.0	81.0	46.8	123.6	156.1	104.9	120.4
			T/2,W/2	LT	76.1	71.8	4.0	77.3	45.7	116.3	153.4	103.2	117.9
			T/2,W/2	ST	75.1	68.9	2.9	75.3	39.3	—	—	—	—
5x6.25	411286	††	T/4,W/4	L	87.6	82.3	11.0	84.6	48.3	118.9	156.3	105.7	122.9
			T/2,W/2	LT	77.2	72.0	3.0	77.8	46.7	106.8‡‡	143.1‡‡	101.1‡‡	119.7‡‡
			T/2,W/2	ST	76.5	70.3	3.0	76.0	42.4	—	—	—	—
					Tentative Minimum Properties								
Up to 0.249 (Area = 20 in.^{2})				L	78	70	7	--	--	--	--	--	--
0.250-0.499 (Area = 20 in.^{2})				L	81	73	7	--	--	--	--	--	--
0.500-1.499 (Area ≤ 20 in.^{2})				L	81	72	7	--	--	--	--	--	--
1.500-2.999 (Area ≤ 20 in.^{2})				L	81	72	7	--	--	--	--	--	--

* Offset equals 0.2 per cent.
† T-Thickness, W-Width
‡ L-Longitudinal, LT-Long-Transverse, ST-Short-Transverse
§ Specimens cleaned ultrasonically; yield strength = offset equals 2 per cent of pin diameter.
** Producer B, others from Producer A.
†† Rectangle
‡‡ Specimens taken near edge of width; location not comparable to those of other shapes. Data not included for determining ratios.

TABLE VII

SPECIFIED MINIMUM TENSILE PROPERTIES FOR 7050 PRODUCTS
(NASC Contract No. N00019-72-C-0512)

Product	Temper	Thickness, in.	Longitudinal Ultimate Strength, ksi	Longitudinal Yield Strength,* ksi	Longitudinal Elongation In 2 in. or 4D, %	Long-Transverse Ultimate Strength, ksi	Long-Transverse Yield Strength,* ksi	Long-Transverse Elongation In 2 in. or 4D, %	Short-Transverse Ultimate Strength, ksi	Short-Transverse Yield Strength,* ksi	Short-Transverse Elongation In 2 in. or 4D, %	Specification
Sheet	T76	0.040-0.249	78	71	8	72	69	8	--	--	-	None
Plate	T73651	0.250-2.000	71	63	9	72	63	6	--	--	-	AMS 4050
		2.001-3.000	71	63	9	72	63	6	68	59	2	
		3.001-4.000	69	60	9	70	60	6	66	56	2	
		4.001-5.000	67	58	9	69	58	5	64	54	2	
		5.001-6.000	66	56	8	67	56	5	63	53	2	
Hand Forgings	T73652	≤2.000	72	63	9	71	61	5	--	--	-	AMS 4108
		2.001-3.000	72	62	9	70	60	5	67	55	4	
		3.001-4.000	71	61	9	70	59	5	67	55	4	
		4.001-5.000	70	60	9	69	58	4	66	54	3	
		5.001-6.000	69	59	9	68	56	4	66	53	3	
		6.001-7.000	68	58	9	67	54	4	65	51	3	
		7.001-8.000	67	57	9	66	52	4	64	50	3	
Die Forgings	T736	≤2.000	72	62	7	--	--	-	68†	56†	5†	AMS 4107
		2.001-4.000	71	61	7	--	--	-	67†	55†	4†	
		4.001-5.000	70	60	7	--	--	-	66†	54†	3†	
		5.001-6.000	70	59	7	--	--	-	66†	54†	3†	
Extruded Shapes	T76511	≤0.249	78	70	7	--	--	-	--	--	-	None
		0.250-0.499	81	73	7	--	--	-	--	--	-	
		0.500-1.499	81	72	7	--	--	-	--	--	-	
		1.500-2.999	81	72	7	--	--	-	--	--	-	

* Offset equals 0.2 per cent.

† Values apply to specimens with axes deviating more than 15 degrees from parallel to forging flow lines.

TABLE VIII

RATIOS AMONG THE TENSILE, COMPRESSIVE, SHEAR AND BEARING PROPERTIES OF 7050-T76 SHEET

(NASC Contract No. N00019-72-C-0512)

Sample Thickness, in.	Sample Number	CYS(L)/TYS(L)	CYS(LT)/TYS(LT)	SUS(*)/TUS(LT)	SUS(L&LT)†/TUS(LT)	BUS(L)/TUS(LT) e/D=1.5 (Flatwise Specimens)	BUS(L)/TUS(LT) e/D=2.0 (Flatwise Specimens)	BYS(L)/TYS(LT) e/D=1.5 (Flatwise Specimens)	BYS(L)/TYS(LT) e/D=2.0 (Flatwise Specimens)	BUS(LT)/TUS(LT) e/D=1.5 (Flatwise Specimens)	BUS(LT)/TUS(LT) e/D=2.0 (Flatwise Specimens)	BYS(LT)/TYS(LT) e/D=1.5 (Flatwise Specimens)	BYS(LT)/TYS(LT) e/D=2.0 (Flatwise Specimens)
0.040	428882	0.973	1.061	0.600	--	1.527	1.945	1.386	1.559	1.547	1.902	1.361	1.641
0.040	428985	1.001	1.073	0.612	--	1.516	2.009	1.393	1.611	1.521	1.935	1.393	1.596
0.063	411378	0.992	1.051	0.598	--	1.495	1.968	1.316	1.545	1.505	1.992	1.320	1.528
0.063	428884	1.008	1.059	0.594	--	1.551	2.012	1.422	1.670	1.551	2.016	1.386	1.670
0.090	411182	1.000	1.086	0.610	--	1.589	2.067	1.456	1.657	1.589	2.061	1.475	1.736
0.090	411183	1.008	1.073	0.607	--	1.593	2.049	1.473	1.656	1.570	2.075	1.464	1.715
0.125	411212	0.996	1.071	0.594	--	1.571	2.020	1.421	1.560	1.562	2.031	1.427	1.630
0.125	411213	0.989	1.073	0.605	--	1.570	2.036	1.417	1.591	1.580	2.023	1.457	1.622
0.187	413150	1.024	1.079	0.598	--	1.577	2.029	1.506	1.734	1.589	2.029	1.525	1.775
0.222	416020	1.034	1.074	0.587	0.638, 0.629	1.584	2.017	1.498	1.608	1.526	2.021	1.429	1.672
0.249	411309	1.001	1.071	0.596	0.595, 0.622	1.592	2.029	1.420	1.583	1.581	2.025	1.423	1.622

* Punch-type shear tests.
† Tests of cylindrical specimens.

Note: Bearing specimens cleaned ultrasonically.

TABLE IX

RATIOS AMONG THE TENSILE, COMPRESSIVE, SHEAR AND BEARING PROPERTIES OF 7050-T73651 PLATE

(NASC Contract No. N00019-72-C-0512)

Sample Thickness,* in.	Sample Number	CYS(L)/TYS(L)	CYS(LT)/TYS(LT)	CYS(ST)/TYS(ST)	SUS(L)/TUS(LT)	SUS(LT)/TUS(LT)	BUS(L)/TUS(LT) e/D=1.5 (Flatwise Specimens)	BUS(L)/TUS(LT) e/D=2.0 (Flatwise Specimens)	BYS(L)/TYS(LT) e/D=1.5 (Flatwise Specimens)	BYS(L)/TYS(LT) e/D=2.0 (Flatwise Specimens)	BUS(LT)/TUS(LT) e/D=1.5 (Flatwise Specimens)	BUS(LT)/TUS(LT) e/D=2.0 (Flatwise Specimens)	BYS(LT)/TYS(LT) e/D=1.5 (Flatwise Specimens)	BYS(LT)/TYS(LT) e/D=2.0 (Flatwise Specimens)
0.500	411372	0.988	1.033	--	0.598	0.579	1.459	1.930	1.358	1.638	1.482	1.899	1.379	1.662
0.500	411184	0.990	1.039	--	0.588	0.584	1.508	1.907	1.390	1.653	1.493	1.939	1.368	1.652
1.000	411185	0.989	1.047	--	0.589	0.579	1.519	1.920	1.424	1.633	1.512	1.973	1.417	1.712
1.000	411050	1.004	1.044	--	0.576	0.573	1.419	1.913	1.353	1.576	1.494	1.906	1.374	1.606
2.000	411186	0.982	1.049	1.109	0.616	0.616	1.542	1.992	1.454	1.694	1.555	2.034	1.485	1.775
2.000	410778	0.980	1.058	1.064	0.615	0.607	1.539	1.966	1.475	1.655	1.527	1.962	1.499	1.695
4.000	410777	0.946	1.056	1.122	0.620	0.618	1.541	1.952	1.522	1.707	1.525	1.966	1.514	1.734
4.000	411187	0.964	1.060	1.092	0.621	0.614	1.570	2.008	1.503	1.742	1.558	2.012	1.498	1.777
6.000	411300	0.952	1.068	1.109	0.641	0.640	1.528	1.972	1.560	1.827	1.565	2.017	1.572	1.844
6.000	411330	0.936	1.074	1.121	0.641	0.633	1.538	1.977	1.564	1.810	1.557	2.015	1.556	1.845

* For 0.500 and 1.000 in. plate and ST direction of 2.000 to 6.000 in. plate specimens located at center of thickness. For L and LT directions of 2.000 to 6.000-in. plate specimens located midway between center and surface of plate.

Note: Bearing specimens cleaned ultrasonically.

TABLE X

RATIOS AMONG THE TENSILE, COMPRESSIVE, SHEAR AND BEARING PROPERTIES OF 7050-T73652 HAND FORGINGS

(NASC Contract No. N00019-72-C-0512)

Sample Size, in.	Sample Number	CYS(L)/TYS(L)	CYS(LT)/TYS(LT)	CYS(ST)/TYS(ST)	SUS(L)/TUS(LT)	SUS(LT)/TUS(LT)	SUS(ST)/TUS(LT)	BUS(L)/TUS(LT) e/D=1.5 (Edgewise Specimens)	BUS(L)/TUS(LT) e/D=2.0 (Edgewise Specimens)	BYS(L)/TYS(LT) e/D=1.5 (Edgewise Specimens)	BYS(L)/TYS(LT) e/D=2.0 (Edgewise Specimens)	BUS(LT)/TUS(LT) e/D=1.5 (Edgewise Specimens)	BUS(LT)/TUS(LT) e/D=2.0 (Edgewise Specimens)	BYS(LT)/TYS(LT) e/D=1.5 (Edgewise Specimens)	BYS(LT)/TYS(LT) e/D=2.0 (Edgewise Specimens)
2x8x72*	411354	1.061	1.072	1.172	0.618	0.603	0.609	1.428	1.981	1.390	1.583	1.519	1.990	1.435	1.684
2-1/2x22x60	411229	0.999	1.053	1.117	0.573	0.573	0.559	1.394	1.831	1.417	1.707	1.484	1.916	1.455	1.724
3-1/2x14x72*	428850	1.062	1.081	1.127	0.603	0.598	0.601	1.427	1.952	1.515	1.777	1.418	1.856	1.512	1.806
3-1/2x22x84	411352	1.033	1.111	1.146	0.624	0.634	0.548	1.334	1.826	1.379	1.642	1.403	1.879	1.376	1.629
4-1/2x22x84	411230	1.024	1.105	1.110	0.594	0.584	0.580	1.385	1.850	1.465	1.759	1.445	1.803	1.445	1.739
4-1/2x22x84	411302	1.021	1.145	1.031†	0.621	0.611	0.595	1.418	1.924	1.560	1.818	1.504	1.923	1.513	1.744
5-1/2x22x45*	428851	1.058†	0.981†	1.096	0.620	0.617	0.594	1.525	1.949	1.478	1.740	1.484	1.968	1.434	1.709
5-1/2x22x60	411353	1.017	1.098	1.127	0.606	0.613	0.585	1.393	1.774	1.405	1.622	1.419	1.845	1.420	1.702
7-1/2x22x42	411231	1.033	1.077	1.111	0.626	0.599	0.597	1.439	1.918	1.447	1.637	1.420	1.777	1.396	1.598
7-1/2x22x42	411232	1.020	1.096	1.148	0.597	0.606	0.575	1.442	1.899	1.420	1.677	1.461	1.870	1.392	1.661

* Producer B, all others Producer A.

† Average of two tests.

Note: Bearing specimens cleaned ultrasonically.

TABLE XI

RATIOS AMONG THE TENSILE, COMPRESSIVE, SHEAR AND BEARING PROPERTIES OF 7050-T736 DIE FORGINGS

(NASC Contract No. N00019-72-C-0512)

Sample Thickness, in.	Sample Number	Die Number	CYS(L)/TYS(L)	CYS(ST)/TYS(ST)	SUS(L)/TUS(L)	SUS(ST)/TUS(L)	BUS(L)/TUS(L) e/D=1.5	BUS(L)/TUS(L) e/D=2.0	BYS(L)/TYS(L) e/D=1.5	BYS(L)/TYS(L) e/D=2.0
							(Edgewise Specimens)			
0.6*	411243	2177	1.020	1.056	0.554	0.577	1.382	1.805	1.281	1.489
0.7	411331	9078	1.030	1.063	0.568	0.568	1.403	1.775	1.267	1.512
1.1	411351	15789	1.042	1.038	0.630	0.618	1.499	1.955	1.414	1.635
1.25	411281	17975	1.048	1.061	0.635	0.589	1.500	1.993	1.491	1.772
1.95	411297	17944	1.106	1.060	c.649	0.628	1.544	1.941	1.469	1.683
3.1*	411392	1364	1.073	1.083	0.592	0.560	1.326	1.821	1.309	1.575
3.5	411332B	8457	1.058	1.053	0.589	0.572	1.357	1.814	1.311	1.594
4.02*	411244	4736	1.059	1.049	0.572	0.563	1.314	1.757	1.290	1.519
4.25	411233	12767	1.043	1.045	0.639	0.604	1.557	2.040	1.500	1.664
5.5	411332A	8457	1.063	1.003	0.611	0.581	1.402	1.821	1.331	1.530
6.1	411303	16392	1.119	1.021	0.665	0.611	1.450	1.900	1.566	1.853

* Producer B; all others Producer A.

Note: Bearing specimens cleaned ultrasonically.

TABLE XII

RATIOS AMONG THE TENSILE, COMPRESSIVE, SHEAR AND BEARING PROPERTIES OF 7050-T76511 EXTRUDED SHAPES

(NASC Contract No. N00019-72-C-0512)

Sample Thickness, or Size, in.	Sample Number	Die Number	TUS(LT)/TUS(L)	TYS(LT)/TYS(L)	CYS(L)/TYS(L)	CYS(LT)/TYS(L)	SUS(L)/TUS(L)	SUS(LT)/TUS(L)	BUS(L)/TUS(L) e/D=1.5 (Flatwise Specimens)	BUS(L)/TUS(L) e/D=2.0 (Flatwise Specimens)	BYS(L)/TYS(L) e/D=1.5 (Flatwise Specimens)	BYS(L)/TYS(L) e/D=2.0 (Flatwise Specimens)	BUS(LT)/TUS(L) e/D=1.5 (Flatwise Specimens)	BUS(LT)/TUS(L) e/D=2.0 (Flatwise Specimens)	BYS(LT)/TYS(L) e/D=1.5 (Flatwise Specimens)	BYS(LT)/TYS(L) e/D=2.0 (Flatwise Specimens)
0.187	411288	86366	1.004	1.013	1.079	1.040	0.557	0.539	1.435	1.868	1.343	1.601	1.448	1.882	1.353	1.606
0.402	411289	191282	0.995	0.966	1.034	1.075	0.589	0.592	1.537	1.959	1.451	1.644	1.566	2.000	1.492	1.795
0.665	411290	213590	0.985	0.983	1.008	1.023	0.573	0.548	1.438	1.902	1.390	1.584	1.495	1.911	1.390	1.671
0.841*	421552	53717	0.986	0.985	1.052	1.011	0.569	0.545	1.472	1.935	1.388	1.625	1.506	1.921	1.398	1.625
1.161	411287	231372	0.987	0.974	1.007	1.037	0.593	0.583	1.530	1.958	1.427	1.627	1.511	1.952	1.407	1.733
1.500x7.5	411284	Rectangle	0.965	0.960	1.027	1.019	0.571	0.568	1.493	1.925	1.351	1.531	1.488	1.933	1.344	1.589
2.000x8.0*	411279	Rectangle	0.942	0.939	1.012	0.996	0.561	0.544	1.482	1.923	1.340	1.528	1.461	1.890	1.348	1.522
3.500x7.5	411285	Rectangle	0.927	0.920	1.020	0.981	0.557	0.543	1.442	1.834	1.292	1.480	1.403	1.812	1.282	1.508
4.000x8.0*	411280	Rectangle	0.900	0.901	1.016	0.970	0.553	0.540	1.461	1.845	1.316	1.511	1.375	1.813	1.295	1.479
5.000x6.25	411286	Rectangle	0.881	0.875	1.030	0.945	0.551	0.533	1.357	1.784	1.234	1.493	--	--	--	--

* Producer B; all others Producer A.

Note: Bearing specimens cleaned ultrasonically.

TABLE XXII

STATISTICAL ANALYSES OF RATIOS AMONG TENSILE, COMPRESSIVE, SHEAR AND BEARING PROPERTIES OF 7050-T76 SHEET

(NASC Contract No. N00019-72-C-0512)

Ratio Cell	CYS(L)/TYS(L)	CYS(LT)/TYS(LT)
1.09		1
1.08		1
1.07		6
1.06		2
1.05		1
1.04		
1.03	1	
1.02	1	
1.01	2	
1.00	4	
0.99	2	
0.98		
0.97	1	
n	11	11
$\bar{R}$	1.009	1.070
σ_R	.01421††	.00963
Min. R	0.980–1.001	1.065

Ratio Cell	SUS(*)/TUS(LT)	SUS(L)/TUS(LT)	SUS(LT)/TUS(LT)
0.64		1	
0.63			1
0.62			1
0.61	3		
0.60	5	1	
0.59	3		
0.58			
n	11	2**	2**
$\bar{R}$	0.600		
σ_R	.00674††		
Min. R	0.598–0.585		

e/D = 1.5

Ratio Cell	BUS(L)/TUS(L)	BUS(LT)/TUS(LT)	BUS(L&LT)/TUS(L&LT)†
1.59	3	2	2
1.58	2	2	2
1.57	2	1	2
1.56		1	
1.55	1‡	2‡	1,‡ 1
1.54			1‡
1.53	1‡	1	
1.52	1‡	1‡	1‡
1.51		1‡	
1.50			1‡
1.49	1‡		
n	4,‡ 7	4,‡ 7	4,‡ 7
$\bar{R}$ ≤0.090 in.	1.522	1.531	1.527
$\bar{R}$ >0.090 in.	1.582	1.571	1.577
σ_R ≤0.090 in.			0.02210
σ_R >0.090 in.			0.01221
Min. R ≤0.090 in.			1.501
Min. R >0.090 in.			1.577

Ratio Cell	BYS(L)/TYS(L)	BYS(LT)/TYS(LT)	BYS(L&LT)/TYS(L&LT)†
1.52		1	1
1.51	1		
1.50	1		
1.49			
1.48		1	
1.47	1		2
1.46	1	2	1
1.45			
1.44			1
1.43		2	
1.42	1,‡ 3	1	2
1.41			
1.40			1‡
1.39	2‡	2‡	1‡
1.38			
1.37			2‡
1.36		1‡	
1.35			
1.34			
1.33			
1.32	1‡	1‡	1‡
n	4,‡ 7	4,‡ 7	4,‡ 7
$\bar{R}$ ≤0.090 in.	1.379	1.365	1.372
$\bar{R}$ >0.090 in.	1.456	1.457	1.457
σ_R ≤0.090 in.			.05829
σ_R >0.090 in.			.03260
Min. R ≤0.090 in.			1.327
Min. R >0.090 in.			1.433

e/D = 2.0

Ratio Cell	BUS(L)/TUS(L)	BUS(LT)/TUS(LT)	BUS(L&LT)/TUS(L&LT)†
2.08		1	
2.07	1		
2.06		1	2
2.05	1		
2.04	1		
2.03	2	4	4
2.02	2	1,‡ 1	1
2.01	2‡		1‡
2.00			
1.99		1‡	
1.98			1‡
1.97	1‡		1‡
1.96			
1.95			
1.94	1‡		
1.93		1‡	
1.92			1‡
1.91			
1.90		1‡	
n	4,‡ 7	4,‡ 7	4,‡ 7
$\bar{R}$ ≤0.090 in.	1.984	1.961	1.972
$\bar{R}$ >0.090 in.	2.035	2.039	2.037
σ_R ≤0.090 in.			.05746
σ_R >0.090 in.			.01810
Min. R ≤0.090 in.			1.908
Min. R >0.090 in.			2.004

Ratio Cell	BYS(L)/TYS(L)	BYS(LT)/TYS(LT)	BYS(L&LT)/TYS(L&LT)†
1.77		1	
1.76			
1.75			1
1.74		1	
1.73	1		
1.72		1	
1.71			
1.70			1
1.69	1		1
1.68			
1.67	2‡	1,‡ 1	1‡
1.66	3		
1.65			
1.64		1‡	1
1.63		1	
1.62		2	
1.61	1,‡ 1		
1.60		2‡	2,‡ 2
1.59			1
1.58	1		
1.57			
1.56	2‡		
1.55			
1.54	1‡		2‡
1.53		1‡	
n	4,‡ 7	4,‡ 7	4,‡ 7
$\bar{R}$ ≤0.090 in.	1.596	1.609	1.603
$\bar{R}$ >0.090 in.	1.627	1.682	1.654
σ_R ≤0.090 in.			.05449
σ_R >0.090 in.			.05984
Min. R ≤0.090 in.			1.538
Min. R >0.090 in.			1.610

* Punch-type shear tests.

† L and LT ratios averaged. Students "t" - test showed no significant difference between the average ratios for L and LT directions and "F" - test showed no significant difference in variability for the L and LT directions.

‡ 0.040 and 0.063-in. thick sheet; analyzed separately from thicker sheet.

** Insufficient data for analyses of data from tests cylindrical specimens.

†† Regression analysis showed significant relationship with thickness. Value shown is $\sigma_e/\sqrt{n}$.

TABLE XIV

STATISTICAL ANALYSES OF RATIOS AMONG TENSILE, COMPRESSIVE, SHEAR AND BEARING PROPERTIES OF 7050-T73651 PLATE

(NASC Contract No. N00019-72-C-0512)

Ratio Cell	CYS(L)/TYS(L)	CYS(LT)/TYS(LT)	CYS(ST)/TYS(ST)
1.12			2
1.11			2
1.10			
1.09			1
1.08			
1.07			
1.06		3	1
1.05		2	
1.04		2	
1.03		1	
1.02			
1.01			
1.00	1		
0.99	3		
0.98	2		
0.97			
0.96	1		
0.95	2		
0.94	1		
n	10	10	6
x̄	0.973	1.053	1.103
$\sigma_{\bar{x}}$	.00855††	.00488††	.01992††
Min. x̄	0.987- 0.932	1.033- 1.061	1.061- 1.087

	Ratio Cell	SUS(L)/TUS(L)	SUS(LT)/TUS(LT)	SUS(L+LT)/TUS(L+LT)†
	0.64	2	1	2
	0.63		1	
	0.62	4	1	3
	0.61		2	1
	0.60	1*		
	0.59	2*		2*
	0.58	1*	3*	1*
	0.57		1*	1*
n		4*, 6	4*, 5	4*, 6
x̄	≤1.500 in.	0.588	0.579	0.583
	>1.500 in.	0.616	0.621	0.624
$\sigma_{\bar{x}}$	≤1.500 in.			.00491††
	>1.500 in.			.00506††
Min. x̄	≤1.500 in.			0.577- 0.562
	>1.500 in.			0.601- 0.625

e/D = 1.5

	Ratio Cell	[illegible]	[illegible]	[illegible]
	1.57	1		
	1.56		3	1
	1.55		1	3
	1.54	4		
	1.53		2	2
	1.52	1*, 1		1*
	1.51	1*	1*	
	1.50			1*
	1.49		2*	
	1.48		1*	
	1.47			1*
	1.46	1*		1*
	1.45			
	1.44			
	1.43			
	1.42	1*		
n		4*, 6	4*, 6	4*, 5
x̄	≤1.500 in.	1.476	1.495	1.486
	>1.500 in.	1.549	1.548	1.545
$\sigma_{\bar{x}}$	≤1.500 in.			.02702
	>1.500 in.			.01156
Min. x̄	≤1.500 in.			1.454
	>1.500 in.			1.536

	Ratio Cell	[illegible]	[illegible]	[illegible]†
	1.57		1	1
	1.56	2	1	1
	1.55			
	1.54			
	1.53			
	1.52	1		1
	1.51		1	
	1.50	1	2	1
	1.49		1	1
	1.48			
	1.47	1		1
	1.46			
	1.45	1		
	1.44			
	1.43			
	1.42	1*	1*	1*
	1.41			
	1.40			
	1.39	1*		
	1.38		1*	1*
	1.37		2*	1*
	1.36	1*		1*
	1.35	1*		
n		4*, 6	4*, 6	4*, 6
x̄	≤1.500 in.	1.381	1.388	1.383
	>1.500 in.	1.513	1.521	1.517
$\sigma_{\bar{x}}$	≤1.500 in.			.02590
	>1.500 in.			.01114††
Min. x̄	≤1.500 in.			1.352
	>1.500 in.			1.448- 1.526

e/D = 2.0

	Ratio Cell	[illegible]	[illegible]	[illegible]
	2.03		1	
	2.02		2	
	2.01	1	1	2
	2.00			1
	1.99	1		1
	1.98	1		
	1.97	2	1*, 1	
	1.96		1	2
	1.95	1		1*
	1.94	1*	1*	
	1.92	1*		1*
	1.91	2*	1*	2*
	1.90		1*	
n		4*, 6	4*, 6	4*, 6
x̄	≤1.500 in.	1.918	1.989	1.923
	>1.500 in.	1.978	2.008	1.989
$\sigma_{\bar{x}}$	≤1.500 in.			.01639
	>1.500 in.			.02709
Min. x̄	≤1.500 in.			1.904
	>1.500 in.			1.871

	Ratio Cell	[illegible]	[illegible]	[illegible]†
	1.85		1	
	1.84		1	1
	1.83	1		1
	1.82			
	1.81	1		
	1.80			
	1.79			
	1.78		1	
	1.77		1	
	1.76			1
	1.75			
	1.74	1		
	1.73		1	1
	1.72			1
	1.71	1	1*	
	1.70			
	1.69	1	1	
	1.68			
	1.67			1*, 1
	1.66		1*	
	1.65	1*, 1	1*	2*
	1.64	1*		
	1.63	1*		
	1.62			
	1.61		1*	
	1.60			
	1.59			1*
	1.58	1*		
n		4*, 6	4*, 6	4*, 6
x̄	≤1.500 in.	1.695	1.658	1.681
	>1.500 in.	1.739	1.778	1.759
$\sigma_{\bar{x}}$	≤1.500 in.			.03514
	>1.500 in.			.03007††
Min. x̄	≤1.500 in.			1.680
	>1.500 in.			1.633- 1.758

† L and LT ratios averaged. Students "t"-test showed no significant difference between the average ratios for L and LT directions and "F"-test showed no significant difference in variability for the L and LT directions.

* 0.5 and 1.0-in. thick plate; analyzed separately from thicker plate.

†† Regression analysis showed significant relationship with thickness. Value shown is $\sigma_e/\sqrt{x}$.

TABLE IV

STATISTICAL ANALYSES OF RATIOS AMONG TENSILE, COMPRESSIVE, SHEAR AND BEARING PROPERTIES OF 7050-T73652 HAND FORGINGS

(NASC Contract No. N00019-72-C-0512)

Ratio Cell	CYS(L)/TYS(L)	CYS(LT)/TYS(LT)	CYS(ST)/TYS(ST)
1.17			1
1.16			
1.15		1	2
1.14			
1.13			2
1.12			1
1.11		1	2
1.10		3	1
1.09			
1.08		2	
1.07		1	
1.06	3		
1.05		1	
1.04			
1.03	2		
1.02	4		
1.00	1		
n	10	9	9
R̄	1.033	1.093	1.128
σ_R	.02123	.02657	.02350
Min. R	1.020	1.077	1.114

Ratio Cell	SUS(L)/TUS(L)	SUS(LT)/TUS(LT)	SUS(L-LT)/TUS(LT)	SUS(ST)/TUS(ST)	SUS(LT-ST)/TUS(ST)†
0.63	1	1	1		
0.62	3	1	2		
0.61	2	3	3	1	4
0.60	1	3	2	3	3
0.59	2		1	2	2
0.58		1		2	
0.57	1	1	1	1	1
0.56					
0.55				1	
n	10	10	10	10	10
R̄	0.608	0.604	0.606	.588	0.596
σ_R					.00827
Min. R					0.591

e/D = 1.5

Ratio Cell	BYS(L)/TYS(L)	BYS(LT)/TYS(LT)	BYS(L-LT)/TYS(LT)†
1.52	1	1	
1.51			
1.50		1	1
1.49			
1.48		2	
1.47			1
1.46		1	1
1.45		1	1
1.44	2		1
1.43	2		1
1.42	1	3	2
1.41			1
1.40		1	
1.39	2		
1.38	1		
1.37			1
1.36			
1.35			
1.34			
1.33	1		
n	10	10	10
R̄	1.418	1.456	1.437
σ_R			.03613
Min. R			1.415

Ratio Cell	BUS(L)/TUS(L)	BUS(LT)/TUS(LT)	BUS(L-LT)/TUS(LT)†
1.56	1		
1.55			
1.54			1
1.53			
1.52			
1.51	1	2	1
1.50			
1.49			
1.48	1		
1.47	1		
1.46			1
1.45	1	2	
1.44			1
1.43		2	
1.42	2	1	1
1.41			3
1.40	1	1	
1.39	1	1	
1.38	1	1	1
n	10	10	10
R̄	1.448	1.438	1.443
σ_R			.04953
Min. R			1.414

e/D = 2.0

Ratio Cell	BUS(L)/TUS(L)	BUS(LT)/TUS(LT)	BUS(L-LT)/TUS(LT)†
1.99		1	1
1.98	1		
1.97		1	
1.96			1
1.95	2		
1.94			
1.93			
1.92	2	2	1
1.91			
1.90	1		1
1.89			
1.88		1	1
1.87		1	1
1.86		1	
1.85	1	1	2
1.84			
1.83	2		1
1.82			
1.81			1
1.80		1	
1.79			
1.78		1	
1.77	1		
n	10	10	10
R̄	1.890	1.883	1.887
σ_R			.05688
Min. R			1.854

Ratio Cell	BYS(L)/TYS(L)	BYS(LT)/TYS(LT)	BYS(L-LT)/TYS(LT)†
1.82	1		
1.81		1	
1.80			
1.79			1
1.78	1		1
1.77			
1.76	1		
1.75			1
1.74	1	2	
1.73			
1.72		1	2
1.71	1	1	
1.70		1	
1.69			
1.68	2	1	1
1.67			1
1.66		1	1
1.65			
1.64	2		1
1.63		1	
1.62	1		1
1.61			
1.60		1	
n	10	10	10
R̄	1.706	1.700	1.703
σ_R			.05858
Min. R			1.668

† LT and ST shear ratios and L and LT bearing ratios averaged. Students "t"-test showed no significant difference between the average ratios with direction and "F"-test showed no significant difference in variability with direction.

TABLE XVI

STATISTICAL ANALYSES OF RATIOS AMONG TENSILE, COMPRESSIVE, SHEAR AND BEARING PROPERTIES
OF 7050-T736 DIE FORGINGS
(NASC Contract No. N00019-72-C-0512)

Ratio Cell	CYS(L)/TYS(L)	CYS(ST)/TYS(ST)
1.12	1	
1.11	1	
1.10		
1.09		
1.08		1
1.07	1	
1.06	3	4
1.05	1	3
1.04	2	1
1.03	1	
1.02	1	1
1.01		
1.00		1

Ratio Cell	SUS(L)/TUS(L)	STS(ST)/TUS(L)	SUS(L+ST)†/TUS(L)
0.67	1		
0.66			
0.65	1		
0.64	1		2
0.63	2		
0.62		2	2
0.61	1	1	1
0.60		1	1
0.59	2	1	
0.58		2	2
0.57	2	2	3
0.56		2	
0.55	1		

e/D = 1.5

Ratio Cell	BUS(L)/TUS(L)
1.56	1
1.55	
1.54	1
1.53	
1.52	
1.51	
1.50	2
1.49	
1.48	
1.47	
1.46	
1.45	1
1.44	
1.43	
1.42	
1.41	
1.40	2
1.39	
1.38	1
1.37	
1.36	1
1.35	
1.34	
1.33	1
1.32	
1.31	1

Ratio Cell	BYS(L)/TYS(L)
1.57	1
1.56	
1.55	
1.54	
1.53	
1.52	
1.51	
1.50	1
1.49	1
1.48	
1.47	1
1.46	
1.45	
1.44	
1.43	
1.42	
1.41	1
1.40	
1.39	
1.38	
1.37	
1.36	
1.35	
1.34	
1.33	1
1.32	
1.31	2
1.30	
1.29	1
1.28	1
1.27	1

e/D = 2.0

Ratio Cell	BUS(L)/TUS(L)
2.04	1
2.03	
2.02	
2.01	
2.00	
1.99	1
1.98	
1.97	
1.96	1
1.95	
1.94	1
1.93	
1.92	
1.91	
1.90	1
1.89	
1.88	
1.87	
1.86	
1.85	
1.84	
1.83	
1.82	2
1.81	2
1.80	
1.79	
1.78	
1.77	1
1.76	1

Ratio Cell	BYS(L)/TYS(L)
1.85	1
1.84	
1.83	
1.82	
1.81	
1.80	
1.79	
1.78	
1.77	1
1.76	
1.75	
1.74	
1.73	
1.72	
1.71	
1.70	
1.69	
1.68	1
1.67	
1.66	1
1.65	
1.64	1
1.63	
1.62	
1.61	
1.60	
1.59	1
1.58	
1.57	1
1.56	
1.55	
1.54	
1.53	1
1.52	1
1.51	1
1.50	
1.49	1

	CYS(L)/TYS(L)	CYS(ST)/TYS(ST)	SUS(L)/TUS(L)	STS(ST)/TUS(L)	SUS(L+ST)†/TUS(L)	e/D = 1.5 BUS(L)/TUS(L)	e/D = 1.5 BYS(L)/TYS(L)	e/D = 2.0 BUS(L)/TUS(L)	e/D = 2.0 BYS(L)/TYS(L)
n	11	11	11	11	11	11	11	11	11
$\bar{R}$	1.050	1.048	0.609	0.588	0.599	1.430	1.384	1.875	1.621
$\sigma_{\bar{R}}$	.02569††	.01787††			.02887	.08521	.10632	.09534	.11548
Min. $\bar{R}$	1.016-1.058	1.047-1.007			.583	1.384	1.326	1.823	1.557

† L and ST ratios averaged. Students 't'-test showed no significant difference between the average ratios for L and ST directions and "F"-test showed no significant difference in variability for the L and ST directions.

†† Regression analysis showed significant relationship with thickness. Value shown in $\sigma_e/\sqrt{R}$.

TABLE XVII

STATISTICAL ANALYSES OF RATIOS AMONG TENSILE, COMPRESSIVE, SHEAR AND BEARING PROPERTIES OF 7050-T76511 EXTRUDED SHAPES
(NASC Contract No. N00019-72-C-0512)

Ratio Cell	TUS(LT)/TUS(L)	TYS(LT)/TYS(L)
1.01		1
1.00	2	
0.99	2	1
0.98	1	1
0.97		2
0.96	1	1
0.95		
0.94	1	1
0.93	1	
0.92		1
0.91		
0.90	1	1
0.89		
0.88	1	
0.87		1
n	10	10
$\bar{x}$	0.957	0.952
$\sigma_{\bar{x}}/\sqrt{n}$	.00741††	.01178††
[illegible]	0.982-0.970	0.983-0.961

Ratio Cell	CYS(L)/TYS(L)	CYS(LT)/TYS(L)
1.08	1	1
1.07		
1.06		
1.05	1	
1.04		2
1.03	3	
1.02	2	2
1.01	3	1
1.00		1
0.99		
0.98		1
0.97		1
0.96		
0.95		1
n	10	10
$\bar{x}$	1.028	1.010
$\sigma_{\bar{x}}/\sqrt{n}$	.00235††	.01616††
[illegible]	1.017-0.986	1.030-0.925

Ratio Cell	SUS(L)/TUS(L)	SUS(LT)/TUS(L)	SUS(L+LT)†/TUS(L)
0.59	2	1	2
0.58		1	
0.57	3	1	1
0.56	3		2
0.55	2	1	4
0.54		5	1
0.53		1	
n	10	10	10
$\bar{x}$	0.567	0.554	0.560
$\sigma_{\bar{x}}/\sqrt{n}$			.01477††
[illegible]			0.557-0.523

e/D = 1.5

Ratio Cell	BUS(L)/TUS(L)	BUS(LT)/TUS(L)	BUS(L+LT)†/TUS(L)
1.57		1	
1.56			
1.55			1
1.54	1		
1.53	1		
1.52			1
1.51		2	
1.50		1	
1.49	1	1	2
1.48	1		
1.47	1		2
1.46	1	1	
1.45		1	
1.44	2		1
1.43	1		
1.42			2
1.41			
1.40		1	
1.39			
1.38			
1.37		1	
1.36	1		1
n	10	9	10
$\bar{x}$	1.465	1.473	1.463
$\sigma_{\bar{x}}/\sqrt{n}$			.03582††
[illegible]			1.477-1.335

Ratio Cell	BYS(L)/TYS(L)	BYS(LT)/TYS(L)	BYS(L+LT)†/TYS(L)
1.49		1	
1.48			
1.47			1
1.46			
1.45	1		
1.44			
1.43	1		
1.42			1
1.41		1	
1.40		1	
1.39	2	1	2
1.38			
1.37			
1.36			
1.35	1	2	2
1.34	2	1	1
1.33			
1.32	1		
1.31			1
1.30			
1.29	1	1	1
1.28	1	1	1
n	10	9	10
$\bar{x}$	1.398	1.368	1.359
$\sigma_{\bar{x}}/\sqrt{n}$			.03780††
[illegible]			1.378-1.222

e/D = 2.0

Ratio Cell	BUS(L)/TUS(L)	BUS(LT)/TUS(L)	BUS(L+LT)†/TUS(L)
2.00		1	
1.99			
1.98			1
1.97			
1.96	2		1
1.95		1	
1.94			
1.93	1	1	2
1.92	2	1	
1.91		1	2
1.90	1		
1.89		1	
1.88		1	1
1.87	1		
1.86			
1.85	1		
1.84			
1.83	1		1
1.82			1
1.81		2	
1.80			
1.79			
1.78	1		1
n	10	9	10
$\bar{x}$	1.893	1.902	1.892
$\sigma_{\bar{x}}/\sqrt{n}$			.03572††
[illegible]			1.913-1.798

Ratio Cell	BYS(L)/TYS(L)	BYS(LT)/TYS(L)	BYS(L+LT)†/TYS(L)
1.79		1	
1.78			
1.77			
1.76			
1.75			
1.74			
1.73		1	
1.72			1
1.71			
1.70			
1.69			
1.68			1
1.67		1	
1.66			
1.65			
1.64	1		
1.63	1		1
1.62	1	1	1
1.61		1	
1.60	1		1
1.59		1	
1.58	1		
1.57			
1.56			1
1.55			
1.54			
1.53	2		1
1.52		1	
1.51	1	1	
1.50			
1.49	1		3
1.48	1	1	
n	10	9	10
$\bar{x}$	1.562	1.614	1.582
$\sigma_{\bar{x}}/\sqrt{n}$			.04870††
[illegible]			1.608-1.385

† L and LT ratios averaged. Students "t"-test showed no significant difference between the average ratios for L and LT directions and "F"-test showed no significant difference in variability for the L and LT directions.

†† Regression analysis showed significant relationship with thickness.

TABLE XVIII

RATIOS FOR COMPUTING DESIGN MECHANICAL PROPERTIES OF 7050-T76 SHEET

Ratio	Thickness, in. 0.040-0.089	0.090-0.187	0.188-0.249
F_{cy} (L)/F_{ty} (L)	0.980	0.990	1.001
F_{cy} (LT)/F_{ty} (LT)	1.065	1.065	1.065
F_{su}/F_{tu} (LT)	0.598*	0.591*	0.585*
F_{bru}/F_{tu} (LT)			
e/D=1.5	1.501	1.577	1.577
e/D=2.0	1.928	1.024	1.024
F_{bry}/F_{ty} (LT)			
e/D=1.5	1.327	1.433	1.433
e/D=2.0	1.538	1.610	1.610

* Based on punch-type shear-test data.

TABLE XIX

RATIOS FOR COMPUTING DESIGN MECHANICAL PROPERTIES
OF 7050-T73651 PLATE

Ratio	Thickness, in. 0.250-0.499	0.500-1.000	1.001-1.500	1.501-2.000	2.001-3.000	3.001-4.000	4.001-5.000	5.001-6.000
F_{cy} (L)/F_{ty} (L)	0.987	0.983	0.979	0.974	0.964	0.955	0.943	0.932
F_{cy} (LT)/F_{ty} (LT)	1.033	1.036	1.040	1.043	1.046	1.051	1.057	1.061
F_{cy} (ST)/F_{ty} (ST)	-	-	-	-	1.061	1.075	1.086	1.087
F_{su}/F_{tu} (LT)	0.577	0.569	0.562	0.601	0.604	0.609	0.619	0.625
F_{bru}/F_{tu} (LT)								
e/D=1.5	1.454	1.454	1.454	1.536	1.536	1.536	1.536	1.536
e/D=2.0	1.904	1.904	1.904	1.971	1.971	1.971	1.971	1.971
F_{bry}/F_{ty} (LT)								
e/D=1.5	1.352	1.352	1.352	1.448	1.459	1.485	1.507	1.526
e/D=2.0	1.600	1.600	1.600	1.633	1.654	1.697	1.733	1.758

TABLE XX

RATIOS FOR COMPUTING DESIGN MECHANICAL PROPERTIES
OF HAND FORGINGS AND DIE FORGINGS

HAND FORGINGS		DIE FORGINGS						
	Thickness, in.		Thickness, in.					
Ratio	$\leq$ 8.000	Ratio	$\leq$ 1.000	1.001-2.000	2.001-3.000	3.001-4.000	4.001-5.000	5.001-6.000
F_{cy} (L)/F_{ty} (L)	1.020	F_{cy} (L)/F_{ty} (L)	1.016	1.022	1.036	1.047	1.053	1.058
F_{cy} (LT)/F_{ty} (LT)	1.077	F_{cy} (T)/F_{ty} (T)	1.047	1.043	1.038	1.029	1.019	1.007
F_{cy} (ST)/F_{ty} (ST)	1.114							
F_{su}/F_{tu} (LT)	0.591	F_{su}/F_{tu} (L)	0.583	0.583	0.583	0.583	0.583	0.583
F_{bru}/F_{tu} (LT)		F_{bru}/F_{tu} (L)						
e/D=1.5	1.415	e/D=1.5	1.384	1.384	1.384	1.384	1.384	1.384
e/D=2.0	1.854	e/D=2.0	1.823	1.823	1.832	1.832	1.832	1.832
F_{bry}/F_{ty} (LT)		F_{bry}/F_{ty} (L)						
e/D=1.5	1.414	e/D=1.5	1.326	1.326	1.326	1.326	1.326	1.326
e/D=2.0	1.668	e/D=2.0	1.557	1.557	1.557	1.557	1.557	1.557

TABLE XXI

RATIOS FOR COMPUTING DESIGN MECHANICAL PROPERTIES
OF 7050-T76511 EXTRUDED SHAPES

Ratio	Thickness, in.									
	≤0.249	0.250-0.499	0.500-0.749	0.750-0.999	1.000-1.499	1.500-1.999	2.000-2.499	2.500-2.999	3.000-3.999	4.000-4.999
F_{tu} (LT)/F_{tu} (L)	0.992	0.987	0.981	0.975	0.963	0.951	0.938	0.924	0.898	0.870
F_{ty} (LT)/F_{ty} (L)	0.983	0.977	0.972	0.967	0.955	0.943	0.931	0.917	0.889	0.861
F_{cy} (L)/F_{ty} (L)	1.017	1.017	1.017	1.017	1.017	1.015	1.012	1.007	0.997	0.986
F_{cy} (LT)/F_{ty} (L)	1.030	1.027	1.022	1.018	1.009	0.999	0.988	0.976	0.951	0.925
F_{su}/F_{tu}	0.557	0.557	0.556	0.556	0.554	0.551	0.547	0.543	0.534	0.523
F_{bru}/F_{tu} (L)										
e/D=1.5	1.477	1.462	1.467	1.462	1.453	1.440	1.425	1.409	1.373	1.335
e/D=2.0	1.913	1.908	1.903	1.897	1.883	1.869	1.852	1.832	1.791	1.748
F_{bry}/F_{ty} (L)										
e/D=1.5	1.374	1.369	1.364	1.359	1.348	1.334	1.318	1.301	1.262	1.222
e/D=2.0	1.608	1.601	1.593	1.585	1.569	1.550	1.527	1.504	1.451	1.395

TABLE XXII

Computed Design Mechanical Properties
of 7050-T76 Sheet

ALLOY SPECIFICATION				
FORM		Sheet		
TEMPER		T76		
CROSS-SECTIONAL AREA, in.^{2}				
THICKNESS, in.		0.040-0.089	0.090-0.187	0.188-0.249
BASIS		Tentative		
MECHANICAL PROPERTIES				
F_{tu}, ksi	L	78	78	78
	LT	78	78	78
F_{ty}, ksi	L	71	71	71
	LT	69	69	69
F_{cy}, ksi	L	69	70	71
	LT	73	73	73
F_{su}, ksi		46	46	45
F_{bru}, ksi	e/D=1.5	117	123	123
	e/D=2.0	150	158	158
F_{bry}, ksi	e/D=1.5	93	99	99
	e/D=2.0	106	111	111
e, per cent	L	8	8	8
	LT	8	8	8
E, 10^3 ksi		10.2		
E_c, 10^3 ksi		10.6		
G, 10^3 ksi		3.9		

TABLE XXIII

Computed Design Mechanical Properties of 7050-T73651 Plate

ALLOY SPECIFICATION	AMS 4050							
FORM	Plate							
TEMPER	T73651							
CROSS-SECTIONAL AREA, in.^{2}								
THICKNESS, in.	0.250-0.499	0.500-1.000	1.001-1.500	1.501-2.000	2.001-3.000	3.001-4.000	4.001-5.000	5.001-6.000
BASIS	S	S	S	S	S	S	S	S
MECHANICAL PROPERTIES								
F_{tu}, ksi L	71	71	71	71	71	69	67	66
LT	72	72	72	72	72	70	68	[illegible]
ST	--	--	--	--	68	66	64	63
F_{ty}, ksi L	63	63	63	63	63	60	58	56
LT	63	63	63	63	63	60	58	56
ST	--	--	--	--	59	56	54	53
F_{cy}, ksi L	62	62	61	61	60	57	54	52
LT	65	65	65	65	66	63	61	59
ST	--	--	--	--	62	60	58	57
F_{sy}, ksi	41	41	40	43	43	42	42	42
F_{bru}, ksi e/D=1.5	104	104	104	110	110	107	104	103
e/D=2.0	137	137	137	142	142	138	134	132
F_{bry}, ksi e/D=1.5	85	85	85	91	91	89	87	85
e/D=2.0	101	101	101	103	103	102	100	98
e, per cent L	9	9	9	9	9	9	9	8
LT	6	6	6	6	6	6	5	5
ST	--	--	--	--	2	2	2	2
E, 10^3 ksi	10.3							
E_c, 10^3 ksi	10.6							
G, 10^3 ksi	3.9							

TABLE XXIV

Computed Design Mechanical Properties of 7050-T73652 Hand Forgings

ALLOY SPECIFICATION	AMS 4108						
FORM	Hand Forgings						
TEMPER	T73652						
CROSS-SECTIONAL AREA, in²							
THICKNESS, in.	≤2.000	2.001-3.000	3.001-4.000	4.001-5.000	5.001-6.001	6.001-7.001	7.001-8.001
BASIS	S	S	S	S	S	S	S
MECHANICAL PROPERTIES							
F_{tu}, ksi L	72	72	71	70	69	68	67
LT	71	70	70	69	68	67	66
ST	--	67	67	66	66	65	64
F_{ty}, ksi L	63	62	61	60	59	58	57
LT	61	60	59	58	56	54	52
ST	--	55	55	54	53	51	50
F_{cy}, ksi L	64	63	62	61	60	59	58
LT	65	64	63	62	60	58	56
ST	--	61	61	60	59	57	55
F_{su}, ksi	42	41	41	41	40	39	39
F_{bru}, ksi e/D=1.5	100	99	99	97	96	95	93
e/D=2.0	131	130	130	128	126	124	122
F_{bry}, ksi e/D=1.5	86	85	83	82	79	76	73
e/D=2.0	101	100	98	96	93	90	86
e, per cent L	9	9	9	9	9	9	9
LT	5	5	5	4	4	4	4
ST	--	4	4	3	3	3	3
E, 10^3 ksi	10.2						
E_c, 10^3 ksi	10.6						
G, 10^3 ksi	3.9						

TABLE XXV

Computed Design Mechanical Properties of 7050-T736 Die Forgings

ALLOY SPECIFICATION	AMS 4107					
FORM	Die Forgings					
TEMPER	T736					
CROSS-SECTIONAL AREA, in²						
THICKNESS, in.	≤1.000	1.001-2.000	2.001-3.000	3.001-4.000	4.001-5.000	5.001-6.000
BASIS	S	S	S	S	S	S
MECHANICAL PROPERTIES						
F_{tu}, ksi L	72	72	71	71	70	70
T	68	69	67	67	66	66
F_{ty}, ksi L	62	62	61	61	60	59
T	56	56	55	55	54	54
F_{cy}, ksi L	63	63	63	63	63	62
T	58	58	57	56	55	54
F_{su}, ksi	42	42	41	41	41	41
F_{bru}, ksi e/D=1.5	99	99	98	98	97	97
e/D=2.0	131	131	129	129	127	127
F_{bry}, ksi e/D=1.5	[illegible]	[illegible]	81	81	79	78
e/D=2.0	[illegible]	96	95	95	93	92
e, per cent L	7	7	7	7	7	7
T	[illegible]	[illegible]	4	4	3	3
E, 10^3 ksi	[illegible]					
E_c, 10^3 ksi	10.7					
G, 10^3 ksi	[illegible]					

TABLE XXVI

Computed Design Mechanical Properties of 7050-T76511 Extruded Shapes

ALLOY SPECIFICATION									
FORM		Extruded Shapes							
TEMPER		T76511							
CROSS-SECTIONAL AREA, in.²		≤20							
THICKNESS, in.		≤0.249	0.250-0.499	0.500-0.749	0.750-0.999	1.000-1.499	1.500-1.999	2.000-2.499	2.500-2.999
BASIS		Tentative							
MECHANICAL PROPERTIES									
F_{tu}, ksi	L	78	81	81	81	81	81	81	81
	LT	77	80	79	79	78	77	76	75
F_{ty}, ksi	L	70	73	72	72	72	72	72	72
	LT	69	71	70	69	69	68	67	66
F_{cy}, ksi	L	71	74	73	73	73	73	73	72
	LT	72	75	73	73	72	72	71	70
F_{su}, ksi		43	45	45	45	45	44	44	44
F_{bru}, ksi	e/D=1.5	115	119	119	118	117	116	115	114
	e/D=2.0	149	154	154	153	152	151	150	148
F_{bry}, ksi	e/D=1.5	96	100	98	98	97	96	95	93
	e/D=2.0	112	117	114	114	113	111	110	108
e, per cent	L	7	7	7	7	7	7	7	7
	LT	--	--	--	--	--	--	--	--
E, 10^3 ksi		10.3							
E_c, 10^3 ksi		10.7							
G, 10^3 ksi		3.9							

TABLE XXVII

RESULTS OF TENSILE AND COMPRESSIVE STRESS-STRAIN AND MODULUS OF ELASTICITY TESTS OF 7050 PRODUCTS
STRESS RANGE: 0 to 25 ksi
(NASC Contract No. N00019-72-C-0512)

Product	Temper	Sample Thickness, in.	Sample Number	Longitudinal Tensile Yield Strength,* ksi	Longitudinal Tensile Modulus, 10^3 ksi	Longitudinal Compressive Yield Strength,* ksi	Longitudinal Compressive Modulus,‡ 10^3 ksi	Long-Transverse Tensile Yield Strength,* ksi	Long-Transverse Tensile Modulus, 10^3 ksi	Long-Transverse Compressive Yield Strength,* ksi	Long-Transverse Compressive Modulus,‡ 10^3 ksi	Short-Transverse Tensile Yield Strength,* ksi	Short-Transverse Tensile Modulus, 10^3 ksi	Short-Transverse Compressive Yield Strength,* ksi	Short-Transverse Compressive Modulus,‡ 10^3 ksi
Sheet	T76	0.040	428862	72.9	10.21	+	10.80	73.3	10.15	+	10.65	--	--	--	--
		0.063	411378	77.9	10.32	77.0	10.53	76.2	10.17	81.2	10.45	--	--	--	--
		0.090	411182	81.1	10.25	77.4	10.43	77.2	10.27	82.0	10.61	--	--	--	--
		0.125	411212	79.3	10.12	79.0	10.55	77.0	10.18	83.3	10.45	--	--	--	--
		0.249	411309	80.0	10.03	79.9	10.35	78.3	10.21	84.0	10.52	--	--	--	--
		Avg.			10.19		10.53		10.20		10.54				
Plate	T73651	0.500	411184	65.1	10.19	66.4	10.50	65.5	10.25	70.1	10.68	--	--	--	--
		1.000	411185	65.4	10.30	65.2	10.50	65.3	10.50	68.1	10.70	--	--	--	--
		2.000	411166	65.9	10.28	64.9	10.48	65.0	10.38	68.4	10.61	--	--	--	--
		4.000	411187	63.1	10.20	61.7	10.55	63.1	10.27	67.3	10.70	57.7	9.97	65.0	10.52
		6.000	411300	60.9	10.13	58.4	10.41	59.8	10.26	63.9	10.54	57.4	10.15	63.9	10.48
		Avg.			10.22		10.49		10.33		10.65		10.06		10.50
Hand Forgings	T73652	2.5	411229	65.7	10.05	66.0	10.44	63.5	10.29	68.6	10.63	--	--	--	--
		3.5	411352	68.5	10.14	71.5	10.52	64.7	10.19	71.2	10.65	63.0	10.18	73.2	10.65
		4.5	411230	59.6	10.13	62.9	10.42	59.4	10.30	64.5	10.69	56.5	10.03	63.2	10.52
		5.5	411353	69.5	10.15	72.6	10.43	65.3	10.28	72.5	10.61	63.5	10.14	71.8	10.51
		7.5	411232	63.9	10.11	64.7	10.31	61.2	10.32	65.5	10.59	57.6	10.12	66.2	10.45
		Avg.			10.12		10.42		10.28		10.63		10.13		10.53
Die Forgings	T736	0.7	411331	69.3	10.51	72.7	10.71	--	--	--	--	63.7	10.18	68.2	10.56
		1.1	411351	68.3	10.03	71.1	10.44	--	--	--	--	67.3	10.27	69.8	10.52
		4.25	411233	69.2	9.96	71.8	10.35	--	--	--	--	67.4	9.90	71.3	10.43
		5.5	411332	69.7	10.32	73.3	10.66	--	--	--	--	65.2	10.22	68.9	10.54
		6.1	411303	62.8	10.13	70.0	10.49	--	--	--	--	65.2	10.16	68.2	10.53
		Avg.			10.19		10.53						10.15		10.52
Extruded Shapes	T76511	0.187	411288	78.1	10.37	78.7	10.76	77.4	10.55	80.3	10.82	--	--	--	--
		0.665	411290	76.6	10.10	79.2	10.44	75.3	10.36	80.0	10.73	--	--	--	--
		1.161	411287	76.5	9.98	78.2	10.40	74.5	10.44	79.9	10.71	--	--	--	--
		3.500	411285	80.7	10.39	83.7	10.67	73.6	10.47	79.2	10.66	69.1	10.08	77.5	10.56
		5.000	411286	82.3	10.36	84.6	10.58	72.3	10.25	76.3	10.58	69.8	10.20	77.8	10.50
		Avg.			10.24		10.57		10.41		10.70		10.14		10.53

* Offset equals 0.2 per cent.

\+ During initial tests and retests specimens buckled before reaching 0.2 per cent offset.

‡ Compressive modulus of elasticity values are 1 to 2 per cent higher when computed within a stress range of zero to the elastic limit based on stress-strain tests to the yield stress. Average values shown in Tables of Computed Design Mechanical Properties (XXII through XXVI) have been adjusted as shown in Table XXVIII.

TABLE XXVIII

SUMMARY OF AVERAGE MODULUS OF ELASTICITY VALUES OF 7050 PRODUCTS
(NASC Contract No. N00019-72-C-0512)

Product	Temper	Average Modulus of Elasticity Values, 10^3 ksi: Tension (0 to 25 ksi)			Compression (0 to 25 ksi)			Average for all Directions*: 0 to 25 ksi		0 to E.L.†
		Longitudinal	Long-Transverse	Short-Transverse	Longitudinal	Long-Transverse	Short-Transverse	Tension	Compression	Compression
Sheet	T76	10.19	10.20	--	10.53	10.54	--	10.2	10.5	10.6‡
Plate	T73651	10.22	10.33	10.06	10.49	10.65	10.50	10.3	10.5	10.6‡
Hand Forgings	T73652	10.12	10.28	10.13	10.42	10.63	10.53	10.2	10.5	10.6‡
Die Forgings	T736	10.19	--	10.15	10.53	--	10.52	10.2	10.5	10.7‡
Extruded Shapes	T76511	10.24	10.41	10.14	10.57	10.70	10.53	10.3	10.6	10.7‡

* Values weighted and rounded to nearest 100 ksi.

† Stress range: 0 to E.L. (elastic limit).

‡ Values are 1 to 2 per cent higher than those for stress range of 0 to 25 ksi. These are the values shown in Tables XXII through XXVI.

TABLE XXIX

RESULTS OF FRACTURE TOUGHNESS TESTS OF 7050-T76 SHEET.
(16-IN. WIDE PANELS-WITH AND WITHOUT ANTI-BUCKLING GUIDES)
(NASC Contract No. N00019-72-C-0512)

Longitudinal (L-T)

Nominal Thickness, in.	Sample Number	Specimen Number*	Specimen Thickness (B), in.	Tensile Yield Strength,* (σ_{ys}) ksi	Total Crack Length, in. Original	Total Crack Length, in. at Failure† (a_c)	Stress at Failure, ksi Gross**	Stress at Failure, ksi σ_n**	σ_n‡‡ / σ_{ys}	K_c, ksi $\sqrt{in.}$*** W	K_c, ksi $\sqrt{in.}$*** WO
0.040	[illegible]	L1(W)	[illegible]	[illegible]	4.00	5.20	28.0	42.5	0.57	85.0	--
		L2(WO)	[illegible]	[illegible]	4.00	4.70	24.5	34.8	0.42	--	70.1
	[illegible]	L1(W)	[illegible]	73.4	3.96	4.41	29.4	40.8	0.56	51.3	--
[illegible]	[illegible]	L1(W)	0.062	[illegible]	1.00	[illegible]	43.3	46.7	0.60	59.7	--
		L2(W)	0.062	[illegible]	2.00	2.16	33.4	38.6	0.50	62.3	--
		L3(W)	0.061	[illegible]	3.00	3.35	26.0	35.4	0.45	56.9	--
		L4(W)	[illegible]	[illegible]	4.00	4.24	21.4	29.2	0.38	57.6	--
		L5(W)	0.062	[illegible]	5.00	5.11	20.4	30.0	0.39	61.4	--
		L6(W)	0.061	[illegible]	6.00	6.14	18.0	29.2	0.38	61.1	--
	[illegible]	L1(W)	0.064	73.3	3.97	5.59	34.8	42.8	0.72	109.3	--
		L2(W)	0.064	73.3	4.00	5.34	32.6	48.9	0.67	100.6	--
		L3(WO)	0.064	73.3	4.01	5.38	28.[illegible]	42.9	0.59	--	88.3
		L4(WO)	0.065	73.3	4.00	6.14	27.[illegible]	40.[illegible]	0.56	--	83.3
		L5(W)	0.064	73.3	6.00	8.45	24.9	53.0	0.72	110.3	--
		L6(W)	0.064	73.3	6.00	7.61	26.3	50.2	0.69	105.4	--
		L7(WO)	0.063	73.3	6.00	10.21	20.5	56.[illegible]	0.77	--	111.4
		L8(WO)	0.064	73.3	6.00	9.19	20.3	47.5	0.65	--	97.3
[illegible]	[illegible]	L1(W)	[illegible]	78.9	4.00	4.19	21.1	28.6	0.36	56.3	--
	[illegible]	L1(W)	[illegible]	76.3	[illegible]	4.75	26.3	37.4	0.48	75.5	--
[illegible]	[illegible]	L1(W)	[illegible]	79.6	4.00	4.19	18.7	24.7	0.31	45.7	--
	[illegible]	L1(W)	[illegible]	[illegible]	4.00	4.62	[illegible]	31.3	0.40	43.0	--
[illegible]	[illegible]	L1(W)	[illegible]	[illegible]	3.98	4.12	17.4	22.7	0.30	45.6	--
		L2(WO)	[illegible]	[illegible]	4.00	4.97	17.9	25.9	0.33	--	52.6
[illegible]	[illegible]	L1(W)	[illegible]	80.2	4.00	[illegible]	19.0	[illegible]	0.32	50.0	--

Transverse (T-L)

Nominal Thickness, in.	Sample Number	Specimen Number*	Specimen Thickness (B), in.	Tensile Yield Strength,† (σ_{ys}) ksi	Total Crack Length, in. Original	Total Crack Length, in. at Failure (a_c)	Stress at Failure, ksi Gross**	Stress at Failure, ksi σ_n**	σ_n‡‡ / σ_{ys}	K_c, ksi $\sqrt{in.}$*** W	K_c, ksi $\sqrt{in.}$*** WO
0.040	[illegible]	T1(W)	0.039	73.5	4.00	4.30	24.51	33.53	0.46	66.4	--
		T2(WO)	0.039	73.5	3.99	4.32	20.11	27.55	0.38	--	56.4
	[illegible]	T1(W)	0.039	73.1	3.86	4.08	22.04	29.59	0.41	57.9	--
[illegible]	[illegible]	T1(W)	0.061	78.2	1.00	1.34	43.3	47.2	0.60	63.2	--
		T2(W)	0.060	78.2	2.00	2.09	33.5	38.6	0.49	61.5	--
		T3(W)	0.060	78.2	3.00	3.29	27.4	34.5	0.44	63.9	--
		T4(W)	0.061	78.2	4.00	4.23	23.0	31.3	0.40	61.8	--
		T5(W)	0.060	78.2	5.00	5.27	20.5	30.5	0.39	62.7	--
		T6(W)	0.060	78.2	6.00	6.19	17.0	27.8	0.36	58.0	--
	[illegible]	T1(W)	0.065	73.0	3.94	4.56	24.8	34.6	0.47	69.4	--
		T2(W)	0.064	73.0	4.00	4.80	25.5	36.5	0.50	73.7	--
		T3(WO)	0.065	73.0	4.00	4.96	22.4	32.5	0.45	--	66.1
		T4(WO)	0.065	73.0	4.00	5.17	23.2	34.2	0.47	--	70.1
		T5(W)	0.065	73.0	6.00	7.80	15.6	38.6	0.53	51.0	--
		T6(W)	0.065	73.0	6.00	6.62	19.7	33.6	0.46	70.5	--
		T7(WO)	0.066	73.0	6.00	7.91	16.7	33.0	0.45	--	69.1
		T8(WO)	0.065	73.0	6.00	8.14	16.2	32.9	0.45	--	68.7
[illegible]	[illegible]	T1(W)	0.089	77.0	4.00	4.34	19.7	27.1	0.35	53.7	--
	[illegible]	T1(W)	0.091	75.5	4.00	4.41	28.9	28.8	0.38	57.4	--
[illegible]	[illegible]	T1(W)	0.125	77.9	4.00	4.13	17.1	23.0	0.30	45.2	--
	[illegible]	T1(W)	0.124	77.2	4.00	4.11	19.3	24.7	0.32	48.3	--
[illegible]	[illegible]	T1(W)	0.227	78.3	4.00	4.43	17.7	24.4	0.31	48.7	--
		T2(WO)	0.222	78.3	4.00	4.15	16.5	23.3	0.29	--	43.9
[illegible]	[illegible]	T1(W)	0.252	78.4	4.00	4.26	17.4	23.7	0.30	46.9	--

* Offset equals 0.[illegible] percent.
* W-with anti-buckling guides; WO-without anti-buckling guides.
† Total crack length at failure (a_c) was obtained by compliance method.
** Gross stress = P_c/BW where P_c=maximum load, B=thickness and W=panel width.
** $\sigma_n = [P_c / B(W-a_c)]$.
*** K_c = [illegible]
‡‡ K_c value valid when $\sigma_n < 0.8\sigma_{ys}$ (all above K_c values are valid).

TABLE XXV

RESULTS OF COMPACT-TENSION FRACTURE TOUGHNESS TESTS OF 7050-T73651 PLATE

(NASC Contract No. N00019-72-C-0512)

Longitudinal (L-T)

Sample Thickness, in.	Sample Number	Tensile Yield Strength,* ksi	Specimen Location	Specimen Number	Specimen Thickness, in.	Crack Length, in.	$2.5\left(\frac{K_Q}{\sigma_{YS}}\right)^2$	K_Q,† ksi$\sqrt{in.}$
0.500	411372	66.1	Full Thick	L1	0.52	1.00	1.05	[illegible](a,b,c)
				L2	0.52	0.99	1.04	42.7(a,b,c)
				Avg				--
.500	411164	66.9	Full Thick	L3	0.52	1.00	0.62	[illegible](a,c)
				L4	0.55	1.01	0.67	35.6(a,c)
				Avg				--
1.000	412185	66.4	Full Thick	L1	1.00	1.02	0.60	32.0
			Full Thick	L2	1.00	1.00	0.58	31.5
				Avg				31.8
1.000	411950	70.2	Full Thick	L1	1.00	1.02	0.62	35.2(c)
			Full Thick	L2	1.00	1.01	0.64	35.7
				Avg				35.4
2.000	411186	65.9	Full Thick	L1	2.00	2.14	0.77	36.6
			Full Thick	L2	2.00	2.12	0.75	36.1
				Avg				36.4
2.000	410778	65.7	Full Thick	L1	2.00	2.13	0.73	35.4
			Full Thick	L2	2.00	2.14	0.74	35.7
				Avg				35.6
4.000	410777	65.3	T/4	L1	2.00	2.15	0.56	30.7
				L2	2.00	2.15	0.57	31.2
				Avg				31.0
4.000	411187	63.7	T/4	L1	2.00	2.10	0.64	32.3
			T/4	L2	2.00	2.09	0.67	32.9
				Avg				32.6
6.000	411380	60.9	T/4	L1	2.01	2.04	0.56	[illegible]
			T/4	L2	2.01	2.05	0.56	28.9
				Avg				28.8
6.000	411330	63.7	T/4	L1	2.00	2.05	0.59	25.2
			T/4	L2	2.00	2.08	0.62	26.1
				Avg				25.6

Long-Transverse (T-L)

Sample Thickness, in.	Tensile Yield Strength,* ksi	Specimen Location	Specimen Number	Specimen Thickness, in.	Crack Length, in.	$2.5\left(\frac{K_Q}{\sigma_{YS}}\right)^2$	K_Q,† ksi$\sqrt{in.}$
0.500	65.7	Full Thick	T1	0.52	1.00	0.87	37.8(a,c)
			T2	0.52	1.01	0.88	38.0(a)
			Avg				--
.500	67.2	Full Thick	T3	0.52	1.00	0.52	30.6(c)
			T4	0.52	1.00	0.57	32.1(e)
			Avg				31.4
1.000	65.4	Full Thick	T1	1.00	0.99	0.39	26.0
		Full Thick	T2	1.00	0.97	0.39	25.9
			Avg				26.0
1.000	70.0	Full Thick	T1	1.00	1.03	0.52	31.8
		Full Thick	T2	1.00	1.05	0.49	31.0
			Avg				31.4
2.000	65.7	Full Thick	T1	2.00	2.16	0.50	29.2
		Full Thick	T2	2.00	2.17	0.50	29.4
			Avg				29.3
2.000	65.5	Full Thick	T1	2.00	2.13	0.47	28.5
		Full Thick	T2	2.00	2.12	0.49	28.8
			Avg				28.6
4.000	64.4	T/4	T1	2.00	2.11	0.43	26.6
		T/4	T2	2.00	2.12	0.41	26.2
			Avg				26.4
4.000	63.2	T/4	T1	2.00	2.13	0.46	27.1
		T/4	T2	2.00	2.17	0.47	27.3
			Avg				27.2
6.000	59.1	T/4	T1	2.01	2.13	0.47	25.7
		T/4	T2	2.01	2.08	0.45	24.5
			Avg				25.1
6.000	62.1	T/4	T1	2.00	2.13	0.38	24.4
		T/4	T2	2.00	2.10	0.39	24.6
			Avg				24.5

Short-Transverse (S-L)

Sample Thickness, in.	Tensile Yield Strength,* ksi	Specimen Location	Specimen Number	Specimen Thickness, in.	Crack Length, in.	$2.5\left(\frac{K_Q}{\sigma_{YS}}\right)^2$	K_Q,† ksi$\sqrt{in.}$
0.500	--	--	--	--	--	--	--
	--	--	--	--	--	--	--
.500	--	--	--	--	--	--	--
	--	--	--	--	--	--	--
1.000	--	--	--	--	--	--	--
	--	--	--	--	--	--	--
1.000	--	--	--	--	--	--	--
	--	--	--	--	--	--	--
2.000	51.5	T/2	S1	0.75	0.72	0.38	24.2(f)
		T/2	S2	0.75	0.69	0.35	22.4
			Avg				23.3
2.000	62.2	T/2	S1	0.75	0.74	0.42	25.6
		T/2	S2	0.75	0.76	0.42	25.6
			Avg				25.6
4.000	60.9	T/2	S1	1.50	1.51	0.47	26.4
		T/2	S2	1.50	1.47	0.47	24.5
			Avg				25.4
4.000	59.7	T/2	S1	1.50	1.45	0.39	25.5(f)
		T/2	S2	1.50	1.48	0.40	25.7
			Avg				25.6
6.000	56.8	T/2	S1	2.01	2.07	0.47	24.7
		T/2	S2	2.01	2.07	0.47	24.7
			Avg				24.7
6.000	59.3	T/2	S1	2.00	2.03	0.37	22.9
		T/2	S2	2.00	2.05	0.37	22.8
			Avg				22.8

* Offset equals 0.2 per cent.

† Valid K_{IC} values were not obtained for the following reasons (letters in parenthesis indicate K_Q values considered meaningful).

a Specimen not thick enough. $2.5(K_Q/\sigma_{YS})^2$ is greater than specimen thickness.
b Fatigue crack too short. $2.5(K_Q/\sigma_{YS})^2$, is greater than crack length
c Excessive yielding before crack extension.
f Fatigue crack front curvature exceeded allowed amount.

TABLE XXXI

RESULTS OF COMPACT-TENSION FRACTURE TOUGHNESS TESTS OF 7050-T73652 HAND FORGINGS
(NASC Contract No. N00019-72-C-0512)

Sample Size, in.	Sample Number	Longitudinal (L-T) Tensile Yield Strength,* ksi	Specimen Number	Specimen Thickness, in.	Crack Length, in.	$2.5\left(\frac{K_c}{\sigma_{YS}}\right)^2$	K_c,† ksi $\sqrt{in.}$	Long-Transverse (T-L) Tensile Yield Strength,* ksi	Specimen Number	Specimen Thickness, in.	Crack Length, in.	$2.5\left(\frac{K_Q}{\sigma_{YS}}\right)^2$	K_Q,† ksi $\sqrt{in.}$	Short-Transverse (S-L) Tensile Yield Strength,* ksi	Specimen Number	Specimen Thickness, in.	Crack Length, in.	$2.5\left(\frac{K_Q}{\sigma_{YS}}\right)^2$	K_Q,† ksi $\sqrt{in.}$
2x8x72‡	411354	72.6	L1	1.50	1.57	0.37	28.0	71.3	T1	1.50	1.53	0.17	18.4(h)	67.6	S1	0.75	0.76	0.19	18.7
			L2	1.50	1.64	0.33	26.2		T2	1.50	1.55	0.18	19.3(h)		S2	0.75	0.77	0.15	18.6
			Avg				27.1		Avg				18.8		Avg				18.6
2-1/2x22x60	411229	67.3	L1	1.50	1.47	0.47	29.3(f)	65.5	T1	1.50	1.58	0.40	26.2	61.3	S1	1.00	1.00	0.23	18.5
			L2	1.50	1.44	0.48	29.6(f)		T2	1.50	1.60	0.43	27.2		S2	1.00	0.99	0.26	19.9
			Avg				29.4		Avg				26.7		Avg				19.2
3-1/2x14x72‡	428850	61.1	L1	1.50	1.53	0.78	33.3	60.2	T1	1.50	1.53	0.33	21.9	56.5	S1	1.50	1.54	0.30	19.4
			L2	1.50	1.55	0.79	34.4		T2	1.50	1.56	0.32	21.7		S2	1.50	1.53	0.29	19.3
			Avg				33.8		Avg				21.8		Avg				19.4
3-1/2x22x84	411352	70.0	L1	1.50	1.56	0.47	30.2	66.0	T1	1.50	1.58	0.30	22.7	64.4	S1	1.50	1.61	0.27	21.1
			L2	1.50	1.53	0.46	30.1		T2	1.50	1.54	0.29	22.5		S2	1.50	1.57	0.28	21.4
			Avg				30.2		Avg				22.6		Avg				21.2
4-1/2x22x54	411302	63.2	L1	1.51	1.48	0.58	30.3(f)	59.3	T1	1.51	1.54	0.31	20.9	61.1	S1	1.51	1.53	0.19	16.8
			L2	1.51	1.51	0.60	30.9		T2	1.51	1.56	0.32	21.2		S2	1.51	1.75	0.38	23.9 d,f,h
															S3	1.50	1.54	0.29	20.7
			Avg				30.6						21.0		Avg				18.8
[illegible]-1/2x22x54	411230	62.1	L1	1.50	1.53	0.92	37.7	50.2	T1	1.50	1.56	0.33	21.9	57.3	S1	1.50	1.60	0.53	26.4 h
			L2	1.5[illegible]	1.55	0.82	35.5		T2	Failed in fatigue		—	—		S2	1.50	1.62	0.53	26.0 h
			Avg				36.6		T3	1.50	1.58	0.28	20.0		S3	1.50	1.56	0.25	18.2
									T4	1.50	1.58	0.25	19.1		S4	1.50	1.56	0.25	18.1
									Avg				20.3		Avg				19.2
5-1/2x22x40‡	426851	60.0	L1	1.50	1.51	0.69	31.5	62.6	T1	1.50	1.54	0.28	21.1	57.1	S1	1.50	1.54	0.28	19.3
			L2	1.50	1.50	0.66	30.8		T2	1.50	1.52	0.29	21.3		S2	1.50	1.50	0.27	18.9
			Avg				31.2		Avg				21.2		Avg				19.1
[illegible]-1/2x22x60	411353	58.8	L1	1.50	1.53	0.61	34.0	66.2	T1	1.50	1.58	0.22	19.7	62.1	S1	1.50	1.53	0.27	20.2
			L2	1.50	1.52	0.56	32.5		T2	1.50	1.56	0.21	19.0		S2	1.50	1.52	0.23	19.0
			Avg				33.2		Avg				19.4		Avg				19.6
7-1/2x22x42	411231	60.9	L1	1.50	1.46	0.76	33.7(c)	60.9	T1	1.50	1.56	0.25	19.2(h)	57.8	S1	Failed in fatigue		—	—
			L2	1.50	1.42	0.69	32.0(c)		T2	Failed in fatigue		—	—		S2	Failed in fatigue		—	—
			Avg				32.8		Avg				19.2		S3	1.50	1.57	0.24	18.0
															S4	1.50	1.52	0.34	21.4
															Avg				19.7
7-1/2x22x42	411232	63.9	L1	1.50	1.41	0.76	35.2(f)	60.7	T1	1.50	1.56	0.23	18.4(h)	58.1	S1	Failed in fatigue		—	—
			L2	1.50	1.40	0.68	33.4(f)		T2	1.50	1.56	0.23	17.9 h		S2	1.50	1.49	0.21	16.9 h
			Avg				34.3		Avg				18.4		S3	1.50	1.54	0.21	16.9(h)
															S4	1.50	1.54	0.20	16.5(h)
															Avg				16.7

* Offset equals 0.2 per cent.
† Valid K_{Ic} values except as noted for the following reasons (letters in parenthesis indicate K_Q values considered meaningful):
c - Excessive yielding before crack extension.
d - Crack length to width ratio not between 0.45 and 0.55.
f - Fatigue crack front curvature exceeded allowed amount.
h - Stress-intensity was too high.
‡ Producer B, others Producer A.

NOTE: Specimens located in center third of thickness and width of forging.

TABLE XXXII

RESULTS OF COMPACT-TENSION FRACTURE TOUGHNESS TESTS OF 7050-T736 DIE FORGINGS
(NASC Contract No. N00019-72-C-0512)

Sample: Approximate Thickness, in.	Sample: Number	Sample: Die Number	Longitudinal (L-T): Tensile Yield Strength, ksi	L-T: Specimen Number	L-T: Specimen Thickness, in.	L-T: Crack Length, in.	L-T: $2.5\left(\frac{K_Q}{\sigma_{YS}}\right)^2$	L-T: K_Q,† ksi $\sqrt{in.}$	Longitudinal (L-S): Tensile Yield Strength, ksi	L-S: Specimen Number	L-S: Specimen Thickness, in.	L-S: Crack Length, in.	L-S: $2.5\left(\frac{K_Q}{\sigma_{YS}}\right)^2$	L-S: K_Q,† ksi $\sqrt{in.}$	Short-Transverse (S-L): Tensile Yield Strength, ksi	S-L: Specimen Number	S-L: Specimen Thickness, in.	S-L: Crack Length, in.	S-L: $2.5\left(\frac{K_Q}{\sigma_{YS}}\right)^2$	S-L: K_Q,† ksi $\sqrt{in.}$
0.6**	411243	2177	—	—	—	—	—	—	75.4	L1	.54	0.74	0.45	32.0^{c} (c)	64.5	S1	0.63	[illegible]	0.25	20.4^{d,h}
										L2	.54	0.75	0.49	33.2		S2	0.63	0.76	0.26	21.5 (d)
										Avg				33.2		S3	0.65	0.84	0.37	24.6 (d)
																S4	0.65	0.84	0.35	28.2
																Avg				23.4
0.7	411331	9078	—	—	—	—	—	—	72.9	L1	1.00	1.02	0.74	39.6	63.5	S1	0.75	0.98	0.40	25.5
										L2	1.00	1.32	0.64	36.9		S2	0.75	1.02	0.43	26.4
										Avg				38.2		Avg				26.0
1.1	411351	15789	—	—	—	—	—	—	69.1	L1	1.13	1.69	0.81	39.2^{d,f}	68.2	S1	1.20	1.68	0.43	28.3^{d,f,h}
										L2	0.88	1.06	0.91	41.7 (e)		S2	1.00	1.09	0.41	27.7
										Avg				41.7		Avg				27.7
1.25	411281	17975	—	—	—	—	—	—	68.0	L1	1.01	1.06	0.68	35.4 (f)	70.4	S1	1.01	1.08	0.30	24.2^{d,f}
										L2	1.01	1.09	0.57	32.6		S2	1.01	1.18	0.37	27.1
										Avg				35.4		Avg				24.2
1.95	411297	17944	—	—	—	—	—	—	68.8	L1	1.51	1.94	0.95	42.4^{d,f}	67.0	S1	1.51	1.83	0.30	23.0^{d,f,h}
										L2	1.51	1.83	0.75	37.7^{d,f}		S2	1.51	1.84	0.31	23.5^{d,f,h}
										Avg				—		Avg				—
2.5**	411392	1364	—	—	—	—	—	—	64.7	L1	1.50	1.69	1.37	47.6^{d,f}	58.9	S1	1.50	1.68	0.36	22.4^{d,f,h}
										L2	1.50	1.68	1.19	44.6^{d,f}		S2	1.50	1.99	0.39	23.3
										Avg				—		Avg				23.3
3.5‡	411332B	8457	70.2	L3	1.30	1.52	0.42	28.7 (f)	—	—	—	—	—	—	68.3	S3	1.50	1.72	0.30	23.7^{d,f,h}
				L4	1.37	1.66	0.36	26.5								S4	1.50	1.72	0.31	24.1^{d,f,h}
				Avg				27.6								S7	1.50	1.57	0.28	22.7^{d,f}
																S8	1.50	1.70	0.28	23.0^{d,f}
																Avg				—
4.02**	411244	4735	69.0	L4	1.50	1.80	1.29	49.6^{d,f}	—	—	—	—	—	—	63.6	S4	1.50	2.03	0.52	29.2^{d,f,h}
4.25 dia	411233	12767	69.3	L1	1.50	1.76	0.86	40.6^{d,f}	—	—	—	—	—	—	66.5	S1	1.50	1.77	0.48	33.2^{d,f}
				L2	1.50	1.62	0.78	38.7								S2	1.50	1.82	0.48	29.1^{d,f}
				Avg				38.7												—
5.5‡	411332A	8457	58.5	L1	1.50	1.64	0.46	29.5^{f}	—	—	—	—	—	—	65.8	S1	1.50	1.58	0.23	20.2 (h)
				L2	1.50	1.66	0.43	28.4^{f}								S2	1.50	1.57	0.23	19.9 (h)
				Avg				29.5								S5	1.50	1.61	0.21	19.0
																S6	1.50	1.61	0.24	20.4
																Avg				19.9
6.1	411303	16392	63.2	L1	1.50	1.63	0.44	26.5^{f}	—	—	—	—	—	—	65.7	S1	1.50	1.67	0.22	19.4^{d,f,h}
				L2	1.51	1.74	0.52	28.8^{d,f}								S2	1.51	1.69	0.24	21.2^{d,f,h}
				Avg				—								S3	1.50	1.53	0.24	20.3
																S4	1.50	1.63	0.28	22.0
																Avg				21.2

* Offset equals 0.2 per cent.
† Valid K_{Ic} values except as noted for the following reasons (letters in parenthesis indicate K_Q values are considered meaningful):
c - Excessive yielding before crack extension.
d - Crack length to width ratio not between 0.45 and 0.55.
f - Fatigue crack front curvature exceeded allowed amount.
h - Stress-intensity was too high.
‡ 411332B - Specimens S7 and S8 from section about 4.5-in. thick; 411332A - Specimen S5 and S6 from section about 7.2-in. thick.
** Producer B, others Producer A.

TABLE XXXIII

RESULTS OF COMPACT-TENSION FRACTURE TOUGHNESS TESTS OF 7075-T76511 EXTRUDED SHAPES

(NASC Contract No. N00019-72-C-0051)

Longitudinal (L-T)

Sample Thickness or Size, in.	Sample Number	Die Number	Tensile Yield Strength,* ksi	Number	Thickness, in.	Crack Length, in.	$2.5\left(\frac{K_Q}{\sigma_{YS}}\right)^2$	K_Q,† ksi $\sqrt{in.}$
0.402	411289	191232	75.[illegible]	L1	0.35	1.49	0.49	33.4 (a,c)
				L2	0.35	1.49	0.57	3[illegible].1 (a,c)
				Avg				—
0.[illegible]5	411290	213592	7[illegible].[illegible]	L1	0.41	1.52	0.45	33.2 c
				L2	0.41	1.52	0.53	35.0 c
				Avg				—
0.841 ‡	41[illegible]62	537[illegible]1	75.2	L1	0.82	1.52	0.24	23.5 c
				L2	0.82	1.50	0.25	23.5 c
				Avg				—
1.161	411287	231392	7[illegible].4	L1	1.13	1.55	0.40	30.7 c
				L2	1.13	1.56	0.43	31.7 c
				Avg				—
1-1/2x7-1/2	411294	Rectangle	73.4	L1	1.38	1.59	0.52	35.9 c (c)
				L2	1.38	1.56	0.57	3[illegible].5 (c)
				Avg				3[illegible].5
2x8 ‡	411275	Rectangle	75.[illegible]	L1	1.50	1.58	0.43	31.2 (f)
				L2	1.50	1.49	0.35	29.4
				Avg				30.3
3-1/2x7-1/2	411285	Rectangle	80.5	L1	1.50	1.52	0.30	28.0
				L2	1.50	1.57	0.41	32.6
				Avg				30.3
4x8 ‡	411260	Rectangle	7[illegible].[illegible]	L1	1.50	1.54	0.40	31.9 c,f
				L2	1.50	1.52	0.32	28.5 (c)
				Avg				26.5
5x[illegible]-1/4	4[illegible]	Rectangle	82.[illegible]	L1	1.50	1.44	0.25	25.8 c
				L2	1.50	1.51	0.27	2[illegible].8 c,f
				Avg				—

Long-Transverse (T-L)

Sample Thickness or Size, in.	Tensile Yield Strength,* ksi	Number	Thickness, in.	Crack Length, in.	$2.5\left(\frac{K_Q}{\sigma_{YS}}\right)^2$	K_Q,† ksi $\sqrt{in.}$
0.402	73.0	LT1	0.35	1.49	0.47	31.6 (a,c)
		LT2	0.35	1.49	0.49	32.7 (a,c)
		Avg				—
0.[illegible]5	75.9	LT1	0.51	1.54	0.39	30.4 (c)
		LT2	0.52	1.50	0.35	28.8 (c)
		Avg				29.6
0.841 ‡	74.1	LT1	0.81	1.47	0.19	20.6
		LT2	0.81	1.51	0.19	20.6
		Avg				20.6
1.161	74.8	LT1	1.13	1.54	0.32	26.5
		LT2	1.13	1.53	0.33	27.0
		Avg				26.8
1-1/2x7-1/2	75.3	LT1	1.38	1.63	0.39	29.7
		LT2	1.38	1.62	0.34	27.7
		Avg				2[illegible].7
2x8 ‡	71.0	LT1	1.50	1.48	0.24	21.9
		LT2	1.50	1.50	0.23	21.3
		Avg				21.6
3-1/2x7-1/2	74.1	LT1	1.50	1.57	0.19	20.2
		LT2	1.50	1.55	0.19	19.9
		Avg				20.0
4x8 ‡	71.[illegible]	LT1	1.50	1.53	0.18	19.5
		LT2	1.50	1.55	0.19	19.6
		Avg				19.5
5x[illegible]-1/4	72.[illegible]	LT1	Failed in Fatigue		—	—
		LT2	1.50	1.54	0.15	17.5
		LT3	1.50	1.50	0.11	17.9
		LT4	1.50	1.52	0.11	17.0
		Avg				17.3

Short-Transverse (S-L)

Sample Thickness or Size, in.	Tensile Yield Strength,* ksi	Number	Thickness, in.	Crack Length, in.	$2.5\left(\frac{K_Q}{\sigma_{YS}}\right)^2$	K_Q,† ksi $\sqrt{in.}$
0.402	—	—	—	—	—	—
		—	—	—	—	—
0.[illegible]5	—	—	—	—	—	—
		—	—	—	—	—
0.841 ‡	—	—	—	—	—	—
		—	—	—	—	—
1.161	—	—	—	—	—	—
		—	—	—	—	—
1-1/2x7-1/2	69.8	S1	0.50	0.50	[illegible]	21.4
		S2	0.50	0.51	[illegible]	23.1
		Avg				[illegible]
2x8 ‡	66.7	S1	0.75	0.80	0.18	[illegible]
		S2	0.75	0.82	0.19	[illegible]
		Avg				18.2
3-1/2x7-1/2	70.9	S1	1.00	0.99	0.13	15.4
		S2	Failed in Fatigue		—	—
		S3	1.25	1.5[illegible]	0.15	17.4 (h)
		S4	1.25	1.5[illegible]	0.15	17.1
		Avg				15.4
4x8 ‡	68.9	S1	1.50	1.54	0.18	18.3
		S2	1.50	1.47	0.17	18.1
		Avg				18.2
5x[illegible]-1/4	70.3	S1	1.50	1.46	0.16	17.9
		S2	1.50	1.49	0.17	18.1
		Avg				18.0

* Offset equals 0.2 per cent.

† Valid K_{Ic} values except as noted for the following reasons (letters in parenthesis indicate K_Q values considered meaningful):
  a. Specimen not thick enough 2.5 $(K_Q/\sigma_{ys})^2$ is greater than specimen thickness.
  c. Excessive yielding before crack extension.
  f. Fatigue-crack front curvature exceeding allowed amount.
  h. Stress-intensity was too high.

‡ Producer B, others Producer A

TABLE XXXIV

AVERAGE AXIAL-STRESS FATIGUE STRENGTHS FOR SMOOTH AND NOTCHED SPECIMENS TESTED IN SALT FOG
R = 0.0 , Transverse Specimens
(NASC Contract No. N00019-72-C-0512)

Alloy	Product	Thickness or Size, in.	Fatigue Strength for Failure at Indicated Number of Cycles: Smooth Specimens 10^5	Smooth Specimens $2x10^6$	Smooth Specimens 10^7	Notched Specimens(a) 10^5	Notched Specimens(a) $2x10^6$	Notched Specimens(a) 10^7
7050-T76	Sheet	0.040	31	20	--	18	11	7.5
7475-T761	Sheet	0.040	28	20	--	16	11	9.5
7050-T76	Sheet	0.125	29	17	--	17	10	7.5
7475-T761	Sheet	0.125	36	26	--	18	13	--
7050-T73651	Plate	1.0 and 4.0	40	19	13	11	6	5
2124-T851	Plate	2.0 and 4.5	37	22	20	14	10	8
7050-T73652	Hand forging	2-1/2x22 and 5-1/2x22	45	18	13	13	7	6
7049-T73	Hand forging	4x16 and 5x20	42	25	--	14	11	11
7175-T736	Hand forging	4x16 and 5x20	42	25	--	12	--	--
7050-T76511	Extruded shape	1.161 and 3.5x7.5	47	19	13	15	8	7

(a) Sheet: $K_t = 3$; Plate, Hand Forging and Extruded Shape: $K_t \geq 12$

TABLE XXXV

RATES OF FATIGUE-CRACK PROPAGATION IN 7050 PRODUCTS
Constant Load Tests

(NASC Contract No. N00019-72-C-0512)

Alloy and Temper	Product	Thickness or Size, in.	Sample No.	Orientation	Data Shown in Figs.	da/dN at Indicated ΔK[(a)] micro-in./cycle: Dry Air 7	Dry Air 12	Humid Air 7	Humid Air 12	Salt Fog 7	Salt Fog 12
7050-T76	Sheet[(b)]	0.040	428985	T-L	146	3.5	13	7.0	28	9.5	40
		0.125	411212	T-L	147	4.6	24	9.0	50	12	58
		0.125	411212	L-T	148	4.7	23	8.5	53	13	53
7475-T761	Sheet[(b)]	0.125	--	T-L	(d)	3.5	20	5.5	32	12	65
7475-T61	Sheet[(b)]	0.125	--	T-L	(d)	4.0	20	8.5	48	14	75
7050-T73651	Plate[(c)]	1	411185	T-L	149	1.8	19	4.2	24	6.5	45
		6	411300	T-L	150	1.4	14	2.6	28	4.0	30
		6	411300	L-T	151	1.2	14	2.6	20	5.0	28
		6	411300	S-L	152	1.5	11	2.6	28	4.0	32
2124-T851	Plate(c)	4.5	--	T-L	(d)	2.5	12	4.0	25	3.0	28
7050-T73652	Hand Forging[(c)]	2-1/2x22	411229	T-L	153	0.9	19	1.5	26	9.0	46
		7-1/2x22	411232	T-L	154	2.8	100	4.4	140	9.0	150
		7-1/2x22	411232	L-T	155	1.2	5	3.8	10	5.5	22
		7-1/2x22	411232	S-L	156	1.9	>200	5.0	>300	5.5	>400
7049-T73	Hand Forging[(c)]	5x20	411232	T-L	(d)	4.0	140	10	160		
7175-T736	Hand Forging[(c)]	5x20	--	T-L	(d)	3.5	24	7.0	40	8.0	36
7050-T76511	Extruded Shape[(c)]	1.161	411287	T-L	157	2.0	12	5.9	30	7.0	42
		1.161	411287	L-T	158	1.0	9	4.5	30	11	44
		5x6-1/4	411286	L-T	159	1.4	5	5.5	22	5.5	28
		5x6-1/4	411286	S-L	160	1.7	>100	6.0	>300	9.0	200

(a) ksi $\sqrt{in.}$
(b) Center notch specimen
(c) Compact specimen
(d) Ref. 12

TABLE XXXVI

RESULTS OF ACCELERATED EXFOLIATION TESTS OF 7050-T76 SHEET
(NASC CONTRACT NO. N00019-72-C-0512)

Sample Thickness, In.	Sample Number	Long Transverse Y.S. (ksi)	Electrical Conductivity % IACS*	Visual Degree of Exfoliation+ EXCO T/10 Plane	Visual Degree of Exfoliation+ MASTMAASIS T/10 Plane
0.040	428882**	73.5	39.4	None	None
0.040	428985	73.1	39.5	None	-----
0.063	428884	73.0	38.5	None	-----
0.063	411378#	78.2	38.7	A	None
0.090	411182#	77.0	38.6	A	None
0.090	411183	75.5	38.2	A	-----
0.125	411212	77.9	37.9	A	-----
0.125	411213#	77.2	37.7	A	None
0.222	416020	78.3	37.7	A	----
0.249	411309#	78.4	35.5	B	None

* Conductivity measurements made on T/10 surface.

+ Ratings based upon ASTM standards for exfoliation (Designation: G34-72), with A thru D categories; D being the most severe.

T/10 panel from this item exposed in the seacoast atmosphere 7/30/73.

** T/10 panel from this item exposed in the seacoast atmosphere 4/29/74.

TABLE XXXVII

RESULTS OF ACCELERATED EXFOLIATION TESTS OF 7050-T73651 PLATE
(NASC CONTRACT NO. N00019-72-C-0512)

Sample Thickness, In.	Sample Number	Long Transverse Y.S. (ksi)	Electrical Conductivity % IACS*	Visual Degree of Exfoliation+ EXCO T/10 Plane	EXCO T/2 Plane	MASTMAASIS T/10 Plane	MASTMAASIS T/2 Plane
0.500	411372	65.7	42.7	A	A	--	--
0.500	411184#	67.2	41.1	A	A	None	None
1.000	411185#	65.4	41.9	A	A	None	None
1.000	411050	70.0	41.1	A	A	--	--
2.000	411186#	65.7	42.2	A	A	None	None
2.000	410778	65.5	40.8	A	A	--	--
4.000	410777#	64.4	40.9	A	A	None	None
4.000	411187	63.2	41.1	A	A	--	--
6.000	411300	59.1	41.1	A	A	--	--
6.000	411330#	62.1	40.9	A	A	None	None

* Conductivity measurements made on T/2 surface.

+ Ratings based upon ASTM standards for exfoliation (Designation: G34-72), with A thru D categories; D being the most severe.

\# T/10 and T/2 panels from this item exposed in the seacoast atmosphere 8/1/73.

TABLE XXXVIII

RESULTS OF ACCELERATED EXFOLIATION TESTS OF 7050-T736 DIE FORGINGS AND 7050-T73652 HAND FORGINGS
(NASC CONTRACT NO. N00019-72-C-0512)

Sample Thickness Range Or Dimensions, In.	Sample Number	Die Number	Longitudinal Y.S. (ksi)	Electrical Conductivity, % IACS*	Visual Degree of Exfoliation+ EXCO T/10 Plane	T/2 Plane
			7050-T736 Die Forgings			
< 1.000**	411243	2177	75.4	41.2	--	None
< 1.000	411331	9078	72.9	41.8	--	None
1.001 - 2.000	411351	15789	69.1	41.3	--	None
1.001 - 2.000	411281	17975	68.0	40.9	--	None
1.001 - 2.000	411297	17944	66.8	40.7	--	None
2.001 - 4.000**	411392	1364	64.7	42.5	--	None
3.001 - 4.000	411332	8457	70.2	41.4	--	None
4.001 - 5.000**	411244	4736	69.0	41.4	--	None
4.001 - 5.000	411233	12757	69.3	41.5	--	None
6.000 - 7.000	411303	16392	63.2	41.3	--	None
			7050-T73652 Hand Forgings			
[illegible].5 x 22	411229	--	67.3	42.2	A	A
7.5 x 22	411231	--	60.9	42.3	A	A

* Conductivity measurements made on T/2 surface.

\+ Ratings based upon ASTM standards for exfoliation (Designation: G34-72), with A thru D categories; D being the most severe.

** Producer B, all others from Producer A.

TABLE XXXIX

RESULTS OF ACCELERATED EXFOLIATION TESTS OF 7050-T76511 EXTRUDED SHAPES
NASC CONTRACT NO. N00019-72-C-0512)

Sample Thickness or Size In.	Sample Number	Longitudinal Y.S. (ksi)	Electrical Conductivity % IACS *	Visual Degree of Exfoliation+ EXCO T/10 Plane	EXCO T/2 Plane	MASTMAASIS T/10 Plane	MASTMAASIS T/2 Plane
0.187	411288	75.9	39.7	A	A	--	--
0.402	411289	75.6	39.0	A	A	--	--
0.665	411290#	78.2	39.2	A	A	None	A
0.841**	411552#	75.2	38.2	A	A	A	A
1.161	411287	76.4	40.2	A	A	--	--
1.5 x 7.5	411284#	78.4	39.7	A	A	A	A
2.0 x 8.0 **	411279	75.6	39.5	A	A	--	--
3.5 x 7.5	411285#	80.5	39.5	A	A	A	A
4.0 x 8.0 **	411280#	79.7	39.4	A	A	A	None
5 x 6.25	411286	82.3	39.3	A	A	--	--

* Conductivity measurements made on T/2 surface.
\+ Ratings based upon ASTM standards for exfoliation (Designation: G34-72), with A thru D categories; D being the most severe.
\# T/10 and T/2 panels from this item exposed in the seacoast atmosphere 8/1/73 or
** Producer B, all others from Producer A.

TABLE XL

RESULTS OF ACCELERATED SCC TESTS OF 7050-T76 SHEET
(NASC CONTRACT NO. N00019-72-C-0512)

Sample		Electrical Conductivity, % IACS *	Tensile Properties			Per Cent Loss in Tensile Strength		Stress-Corrosion Cracking Data			
Thickness, In.	Number		TS ksi	YS ksi	% El.	Unstressed	75% YS	75% Y.S. F/N+	75% Y.S. Days	Preforms F/N	Preforms Days
0.040	428882	39.4	81.6	73.5	10.0			0/2	OK 112	0/2	OK 146
0.063	411378	38.7	84.3	78.2	10.0	26	47	0/2	OK 182	0/2	OK 182
0.090	411182	38.6	83.9	77.0	11.0	24	39	0/2	OK 182	0/2	OK 182
0.125	411213	37.7	83.0	77.2	11.5	23	30	0/2	OK 182	0/2	OK 182
0.249	411309	35.5	83.5	78.4	13.0	33	45	0/2	OK 182	0/2	OK 182

Note: Test specimens: Long-transverse sheet tensile and preforms. 0.040 and 0.063-In. gauges tested full thickness, other gauges machined on one surface to 0.063 in. and rolled surface stressed in tension.

Test environment: 3.5% NaCl - Alternate Immersion per Federal Method 823. Maximum test duration 182 days.

* Conductivity measurements made on T/2 surface.

\+ F/N denotes number of specimens failed over number of specimens exposed.

TABLE XLI

RESULTS OF ACCELERATED SCC TESTS OF 7050-T73651 PLATE
(NASC CONTRACT NO. N00019-72-C-0512)

Sample Thickness, in.	Sample Number	Electrical Conductivity, % IACS*	Test Direction	Tensile Properties T.S. ksi	Tensile Properties Y.S. ksi	Tensile Properties % El.	Percent Loss in Tensile Strength: Unstressed	75% Y.S.	45 ksi	35 ksi	25 ksi	Stress-Corrosion Cracking Data: 75% Y.S. F/N+	75% Y.S. Days	45 ksi F/N	45 ksi Days	35 ksi F/N	35 ksi Days	25 ksi F/N	25 ksi Days
0.500	411372	42.7	L	75.9	66.1	15.7	27	71	--	--	--	0/3	OK182	--	--	--	--	--	--
			LT	75.3	65.7	15.7	32	99	--	--	--	2/3	182,182 (1OK 182)	--	--	--	--	--	--
0.500	411184	41.9	L	76.3	66.9	15.0	27	78	--	--	--	1/3	182,2-OK182	--	--	--	--	--	--
			LT	76.5	67.2	14.3	31	--	--	--	--	3/3	101, 182,182	--	--	--	--	--	--
2.000	411186	42.2	ST	72.9	61.5	7.8	31	--	67	66	52	--	--	2/3	72,81, 1-OK84	1/3	83,2-OK84	0/3	OK84
2.000	410778	40.8	ST	70.9	62.2	4.9	29	--	--	67	44	--	--	3/3	70,76 83	1/3	79,2-OK84	0/3	OK84
4.000	410777	40.9	L	74.0	65.3	12.0	36	--	--	--	--	3/3	118, 148,182	--	--	--	--	--	--
			LT	75.6	64.4	11.0	34	81	--	--	--	0/3	OK182	--	--	--	--	--	--
			ST	72.9	60.9	6.4	38	--	56	49	45	--	--	0/3	OK84	0/3	OK84	0/3	OK84
4.000	411187	41.1	L	72.0	63.7	11.0	33	76	--	--	--	2/3	153,2-OK182	--	--	--	--	--	--
			LT	73.3	63.2	10.0	37	--	--	--	--	3/3	112, 129,182	--	--	--	--	--	--
			ST	69.9	59.7	7.1	34	--	70	62	46	--	--	2/3	73,76, 1-OK84	0/3	OK84	0/3	OK84

Note: 0.125-in. diameter tensile specimens exposed to 3.5% NaCl-Alternate Immersion per Federal Method 823. Maximum test duration 84 days for short-transverse (ST) and 182 days for longitudinal (L) and long-transverse (LT) specimens.

* Conductivity Measurements made on T/2 surface.

\+ F/N denotes number of specimens failed over number of specimens exposed.

TABLE XLII

RESULTS OF ACCELERATED SCC TESTS OF 7050-T73652 HAND FORGINGS
(NASC CONTRACT NO. N00019-72-C-0512)

Sample Dimensions, In.	Sample Number	Electrical Conductivity % IACS *	Test Direction	Tensile Properties TS ksi	Tensile Properties YS ksi	Tensile Properties % El.	Per Cent Loss in Tensile Strength: Unstressed	75% YS	45 ksi	35 ksi	25 ksi	Stress-Corrosion Cracking Data: 75% YS F/N +	75% YS Days	45 ksi F/N	45 ksi Days	35 ksi F/N	35 ksi Days	25 ksi F/N	25 ksi Days
2 x 8 **	411354	40.7	ST	78.7	67.6	4.7	38	--	--	66	43	---	--	3/3	75, 82, 84	1/3	82, 2-OK 84	0/3	OK 84
2.5 x 22	411229	42.2	L	76.7	67.3	10.5	35	78	--	--	--	2/3	182, 182 (1 OK 182)	---	--	---	--	---	--
			LT	75.9	65.5	13.0	37	63	--	--	--	1/3	160 (2 OK 182)	---	--	---	--	---	--
			ST	74.3	61.3	10.0	32	--	--	54	43	---	--	3/3	53, 73, 78	2/3	52, 80, 1-OK 84	0/3	OK 84
4.5 x 22	411302	42.9	L	72.2	63.2	11.5	35	70	--	--	--	0/3	OK 182	---	--	---	--	---	--
			LT	70.1	59.3	10.5	44	--	--	--	--	3/3	144, 146, 182	---	--	---	--	---	--
			ST	71.5	61.1	7.1	40	--	56	49	43	---	--	0/3	OK 84	1/3	42, 2-OK 84	0/3	OK 84
5.5 x 22	411353	41.4	ST	73.4	62.1	6.0	34	--	--	45	39	---	--	3/3	71, 82, 84	0/3	OK 84	0/3	OK 84
7.5 x 22	411231	42.3	L	71.0	60.9	13.0	35	67	--	--	--	1/3	182 (2 OK 182)	---	--	---	--	---	--
			LT	70.9	60.9	5.5	50	--	--	--	--	3/3	66, 69, 69	---	--	---	--	---	--
			ST	69.5	57.8	5.0	35	--	52	45	37	---	--	1/3	84, 2-OK 84	0/3	OK 84	0/3	OK 84

Note: 0.125 in. diameter tensile specimens exposed to 3.5% NaCl - Alternate Immersion per Federal Method 823. Maximum test duration 84 days for short-transverse (ST) and 182 days for longitudinal (L) and long-transverse (LT) specimens.

* Conductivity measurements made on T/2 surface.

\+ F/N denotes the number of specimens failed over number of specimens exposed.

** Producer B, all others from Producer A.

TABLE XLIII

RESULTS OF ACCELERATED SCC TESTS OF 7050-T736 DIE FORGINGS
(NASC CONTRACT NO. N00019-72-C-0412)

Sample Thickness Range In.	Sample Number	Die No.	Electrical Conductivity % IACS*	Test Direction	Tensile Properties TS ksi	Tensile Properties YS ksi	Tensile Properties % El	[illegible]	Per Cent Loss In Tensile Strength 75% YS	Per Cent Loss In Tensile Strength 45 ksi	Per Cent Loss In Tensile Strength 35 ksi	Per Cent Loss In Tensile Strength 25 ksi	Stress-Corrosion Cracking Data 75% YS F/N+	75% YS Days	45 ksi F/N	45 ksi Days	35 ksi F/N	35 ksi Days	25 ksi F/N	25 ksi Days
<1.000**	411243	2177	41.2	ST	73.8	64.5	8.0	31	--	--	58	42	---	---	3/3	66,74, 81	0/3	OK 84	0/3	OK 84
<1.000	411331	9078	41.8	ST	73.1	63.5	9.0	36	--	87	65	50	---	---	2/3	36,45, 1-OK84	2/3	84,84, 1 OK	0/3	OK 84
1.001-2.000	411351	15789	41.3	L	76.0	69.1	8.5	30	--	--	--	--	3/3	124,143, 170	---	---	---	---	---	---
				ST	75.2	68.1	7.5	30	--	--	50	40	---	---	3/3	71,77,83	0/3	OK84	0/3	OK84
1.001-2.000	411281	17975	40.9	ST	75.3	66.7	7.0	33	--	--	--	45	---	---	3/3	38,41, 41	3/3	46,58, 69	0/3	OK 84
1.001-2.000	411297	17944	40.7	ST	74.5	68.0	6.5	28	--	--	58	38	---	---	3/3	45,53, 59	1/3	81,2-OK84	0/3	OK 84
2.001-4.000**	411392	1364	42.5	ST	65.6	58.9	3.5	26	--	--	72	52	---	---	3/3	23,28, 41	2/3	54,69, 1-OK84	1/3	69,2-OK84
2.001-4.000	411332	8457	41.4	ST	75.7	68.3	7.1	35	--	--	--	49	--	--	3/3	36,36, 56	3/3	39,53, 56	0/3	OK84
4.001-5.000**	411244	4736	41.4	ST	71.3	63.6	5.0	30	--	--	55	54	--	--	3/3	46,57,64	1/3	83,2 OK 84	0/3	OK84
4.001-5.000	411233	12767	41.5	L	75.6	69.3	14.0	36	--	--	--	--	3/3	169,170, 182	---	---	---	---	---	---
				ST	74.4	66.5	7.1	32	--	--	--	42	---	---	3/3	42,51, 58	3/3	33,69, 49	0/3	OK84
6.001-7.000	411303	16392	41.3	ST	72.9	65.7	4.0	42	--	--	--	50	---	---	3/3	30,30, 45	3/3	51,74, 75	1/3	84,2-OK 84

Note: 0.125 In. diameter tensile specimens exposed to 3.5% NaCl - Alternate Immersion per Federal Method 823. Maximum test duration 84 days for short-transverse (ST) and 182 days for longitudinal (L) specimens.

* Conductivity measurements made on T/2 surface.

\+ F/N denotes the number of specimens failed over number of specimens exposed.

** Producer B, all others from Producer A.

TABLE [illegible]

RESULTS OF ACCELERATED SCC TESTS OF 7050-T76511 EXTRUDED SHAPES
(NASC CONTRACT NO. N00019-72-C-0512)

Sample: Thickness or Size, In.	Sample: Number	Electrical Conductivity % IACS*	Test Direction	Tensile Properties: TS ksi	Tensile Properties: YS ksi	Tensile Properties: % El.	Per Cent Loss in Tensile Strength: Unstressed	75% YS	45 ksi	35 ksi	25 ksi	Stress-Corrosion Cracking Data: 75% YS F/E†	Days	45 ksi F/E	Days	35 ksi F/E	Days	25 ksi F/E	Days
0.402	411289	39.0	L	83.8	75.6	14.0	33	--	--	--	--	3/3	67, 182, 182	---	--	---	--	---	--
			LT	83.4	73.0	10.0	35	--	--	--	--	3/3	74, 104, 182	---	--	---	--	---	--
0.665	411290	39.2	L	85.4	78.2	14.3	34	--	--	--	--	3/3	87, 174, 182	---	--	---	--	---	--
			LT	84.1	76.9	12.9	37	--	--	--	--	3/3	70, 88, 90	---	--	---	--	---	--
0.541**	411552	38.2	L	82.8	75.2	11.0	35	--	--	--	--	3/3	94, 100, 147	---	--	---	--	---	--
			LT	81.6	74.1	11.0	33	--	--	--	--	3/3	80, 87, 91	---	--	---	--	---	--
1.5 x 7.5	411285	39.7	ST	82.3	69.8	8.0	45	--	--	--	--	---	--	3/3	4, 4, 4	3/3	3, 3, 4	3/3	10, 45, 66++
2.0 x 9.0**	4112[illegible]	39.5	ST	76.0	66.7	6.0	35	--	--	--	69	---	--	3/3	38, 49, 53	3/3	56, 62, 71	1/3	71, 2-OK 84
3.5 x 7.5	411285	39.5	L	86.6	80.5	11.0	34	--	--	--	--	3/3	83, 86, 116	---	--	---	--	---	--
			LT	80.3	74.1	7.0	35	--	--	--	--	3/3	58, 60, 63	---	---	---	---	---	--
			ST	79.9	70.9	2.9	42	--	--	--	52	---	--	3/3	12, 14, 14	3/3	29, 39, 39	1/3	77, 2-OK 84
4.0 x 8.0**	411290	39.4	ST	75.1	65.9	2.9	36	--	--	49	41	---	--	3/3	45, 60, 70	1/3	73, 2-OK 84	0/3	OK 84

Note: 0.125-In. diameter tensile specimens exposed to 3.5% NaCl - Alternate Immersion per Federal Method 823. Maximum test duration 84 days for short-transverse (ST) and 182 days for longitudinal (L) and long transverse (LT) specimens.

* Conductivity measurements made on [illegible] surface.

† F/E denotes the number of specimens failed over number of specimens exposed.

** Producer [illegible], all others from Producer A.

++ Supplementary test results for specimens stressed at 25, 20 and 15 ksi:

Stress, ksi	F/E	Days
25	5/5	30, 30, 30, 84, 84
20	3/5	84, 84, 84, 2-OK-84
15	0/5	OK-84

TABLE XLV

STATUS OF ATMOSPHERIC SCC TESTS OF 7050-T76 SHEET
(NASC Contract No. N00019-72-C-0512)

Sample: Thickness In.	Sample: Number	Stress-Corrosion Cracking Data: 75% Y.S. F/N+	75% Y.S. Days	Preforms F/N+	Preforms Days
		Seacoast Atmosphere			
0.040	428382	0/2	OK - 354	0/2	OK - 417
0.063	411378	0/2	OK - 606	0/2	OK - 606
0.090	411182	0/2	OK - 606	0/2	OK - 606
0.125	411213	0/2	OK - 606	0/2	OK - 606
0.249	411309	0/2	OK - 606	0/2	OK - 606
		Industrial Atmosphere			
0.040	428882	0/2	OK - 373	0/2	OK - 430
0.063	411378	0/2	OK - 660	0/2	OK - 660
0.090	411182	0/2	OK - 660	0/2	OK - 660
0.125	411213	0/2	OK - 660	0/2	OK - 660
0.249	411309	0/2	OK - 660	0/2	OK - 660

Note: Test Specimens: Long-transverse sheet tensile and preforms, 0.040 and 0.063 in. gauges tested full thickness, other gauges machined on one surface to 0.063 in. and rolled surface stressed in tension.

+ F/N denotes number of specimens failed over number exposed.

TABLE XLVI

STATUS OF ATMOSPHERIC SCC TESTS OF 7050-T73651 PLATE (NASC Contract No. NC0019-72-C-0512)

Sample		Stress-Corrosion Cracking Data					
		45 ksi		35 ksi		25 ksi	
Thickness In.	Number	F/N+	Days	F/N	Days	F/N	Days
				Seacoast Atmosphere			
2.0	411186	0/3	OK - 730	0/3	OK - 730	0/3	OK - 730
2.0	410778	0/3	OK - 730	0/3	OK - 730	0/3	OK - 730
4.0	410777	0/3	OK - 730	0/3	OK - 730	0/3	OK - 730
4.0	411187	0/3	OK - 730	0/3	OK - 730	0/3	OK - 730
				Industrial Atmosphere			
2.0	411186	0/3	OK - 763	0/3	OK - 763	0/3	OK - 763
2.0	410778	0/3	OK - 763	0/3	OK - 763	0/3	OK - 763
4.0	410777	0/3	OK - 763	0/3	OK - 763	0/3	OK - 763
4.0	411187	0/3	OK - 763	0/3	OK - 763	0/3	OK - 763

Note: 0.125 in. diameter short-transverse tensile specimens.

+ F/N denotes number of specimens failed over number exposed.

TABLE XLVII

STATUS OF ATMOSPHERIC SCC TESTS OF 7050-T73652 HAND FORGINGS
(NASC Contract No. N00019-72-C-0512)

Sample Dimensions In.	Sample Number	Stress-Corrosion Cracking Data 45 ksi F/N+	45 ksi Days	35 ksi F/N	35 ksi Days	25 ksi F/N	25 ksi Days
			Seacoast Atmosphere				
2 x 8**	411354	2/3	360,360,(1-OK-605)	0/3	OK - 605	1/3	360 (2-OK-605)
2.5 x 22	411229	0/3	OK - 605	0/3	OK - 605	0/3	OK - 605
4.5 x 22	411302	0/3	OK - 605	0/3	OK - 605	0/3	OK - 605
5.5 x 22	411353	1/3	539, (2-OK-605)	0/3	OK - 605	0/3	OK - 605
7.5 x 22	411231	0/3	OK - 605	0/3	OK - 605	0/3	OK - 605
			Industrial Atmosphere				
2 x 8**	411354	0/3	OK - 665	0/3	OK - 665	0/3	OK - 665
2.5 x 22	411229	0/3	OK - 665	0/3	OK - 665	0/3	OK - 665
4.5 x 22	411302	0/3	OK - 665	0/3	OK - 665	0/3	OK - 665
5.5 x 22	411353	0/3	OK - 665	0/3	OK - 665	0/3	OK - 665
7.5 x 22	411231	0/3	OK - 665	0/3	OK - 665	0/3	OK - 665

Note: 0.125 in. diameter short-transverse tensile bars.

\+ F/N denotes number of specimens failed over number exposed.

** Producer B; all others from Producer A.

TABLE XLVIII

STATUS OF ATMOSPHERIC SCC TESTS OF 7050-T736 DIE FORGINGS
(NASC Contract No. N00019-72-C-0512)

Sample		Stress-Corrosion Cracking Data					
Thickness Range, In.	Number	45 ksi F/N+	45 ksi Days	35 ksi F/N	35 ksi Days	25 ksi F/N	25 ksi Days
		Seacoast Atmosphere					
<1.000**	411243	0/3	OK - 605	0/3	OK - 605	0/3	OK - 605
<1.000	411331	0/3	OK - 605	0/3	OK - 605	0/3	OK - 605
1.001-2.000	411351	0/3	OK - 605	0/3	OK - 603	0/3	OK - 605
1.001-2.000	411281	1/3	139, (2-OK-605)	1/3	271, (2-OK-605)	0/3	OK - 605
1.001-2.000	411297	0/2	OK - 605	0/3	OK - 605	0/3	OK - 605
2.001-4.000**	411392	0/3	OK - 605	0/3	OK - 605	0/3	OK - 605
2.001-4.000	411332	3/3	139,139,139	2/3	139,360,(1-OK-605)	0/3	OK - 605
4.001-5.000**	411244	0/3	OK - 605	0/3	OK - 605	0/3	OK - 605
4.001-5.000	411233	3/3	139,139,185	3/3	271,360,360	0/3	OK - 605
6.001-7.000	411303	3/3	139,139,139	3/3	139,139,360	0/3	OK - 605
		Industrial Atmosphere					
<1.000**	411243	0/3	OK - 673	0/3	OK - 673	0/3	OK - 673
<1.000	411331	0/3	OK - 673	0/3	OK - 673	0/3	OK - 673
1.001-2.000	411351	0/3	OK - 605	0/3	OK - 605	0/3	OK - 605
1.001-2.000	411281	0/3	OK - 673	0/3	OK - 673	0/3	OK - 673
1.001-2.000	411297	0/3	OK - 673	0/3	OK - 673	0/3	OK - 673
2.001-4.000**	411392	0/3	OK - 605	0/3	OK - 605	0/3	OK - 605
2.001-4.000	411332	0/3	OK - 673	0/3	OK - 673	0/3	OK - 673
4.001-5.000**	411244	0/3	OK - 605	0/3	OK - 605	0/3	OK - 605
4.001-5.000	411233	1/3	329, (2-OK-673)	0/3	OK - 673	0/3	OK - 673
6.001-7.000	411303	0/3	OK - 673	0/3	OK - 673	0/3	OK - 673

Note: 0.125 in. diameter short-transverse tensile specimens.

\+ F/N denotes number of specimens failed over number exposed.

** Producer B; all others from Producer A.

TABLE XLIX

STATUS OF ATMOSPHERIC SCC TESTS OF 7050-T76511 EXTRUDED SHAPES
(NASC Contract No. N00019-72-C-0512)

Sample Dimensions, In.	Sample Number	45 ksi F/N+	45 ksi Days	35 ksi F/N	35 ksi Days	25 ksi F/N	25 ksi Days
Seacoast Atmosphere							
1.5 x 7.5	411284	3/3	75,75,75	3/3	75,75,75	2/3	75,445,(1-OK-680)
2.0 x 8.0**	411279	3/3	75,359,445	1/3	445,(2-OK-680)	0/3	OK - 680
3.5 x 7.5	411285	3/3	75,75,75	3/3	75,75,359	1/3	224,(2-OK-680)
4.0 x 8.0**	411280	3/3	224,224,224	3/3	224,224,359	0/3	OK - 680
Industrial Atmosphere							
1.5 x 7.5	411284	0/3	OK- 721	0/3	OK - 721	0/3	OK - 721
2.0 x 8.0**	411279	0/3	OK - 721	0/3	OK - 721	0/3	OK - 721
3.5 x 7.5	411285	0/3	OK - 721	0/3	OK - 721	0/3	OK - 721
4.0 x 8.0**	411280	0/3	OK - 721	0/3	OK - 721	0/3	OK - 721

Note: 0.125 in. diameter short-transverse tensile bars.

+ F/N denotes number of specimens failed over number exposed.

** Producer B; all others from Producer A.

TABLE L

SUMMARY OF CORROSION PERFORMANCE OF ALLOY 7050 PRODUCTS RELATIVE TO ANTICIPATED CORROSION TARGETS*
(NASC Contract No. N00019-72-C-0512)

Product	Temper	No. Lots#	Thick. Range, In.	Corrosion Targets+ SCC Resistance Of:	Corrosion Targets+ Exfoliation Resistance Of:	Met Target? SCC	Met Target? Exfoliation
Sheet	T76	5	0.040-0.249	7075-T76	7075-T76	Yes	Yes
Plate	T73651	6	0.500-4.000	< 7075-T7351 > 7075-T7651	7075-T7351	Yes	No**
Hand Forgings	T73652	5	2.000-7.500	7175-T736	7175-T736	Yes	Yes
Die Forgings	T736	10	< 1.000-7.000	7175-T736	7175-T736	Yes	Yes
Extrusions	T76511	7	0.402-4.000	7075-T76511	7075-T76511	Yes++	Yes

* Anticipated performance per Alcoa Green Letter: Alcoa Alloy 7050, (4-73).

\+ Principal corrosion target boxed; when no corrosion target is boxed, the primary target for the product was some other characteristic such as tensile properties.

\# Designates number of lots SCC tested with smooth specimens. Exfoliation tests conducted on all lots of each product but hand forgings. Two lots tested for latter.

** Exfoliation was degree E-A; 7075-T7351 showed no exfoliation.

++ One section required additional aging at ATC.

TABLE LI

RESULTS OF SCC TESTS OF PRECRACKED SPECIMENS FROM 7050-T73651 PLATE
(NASC CONTRACT NO. N00019-72-C-0512)

Sample Thickness, In.	Sample Number	Test Specimen	C.O.D., In.	Crack Length, In. Initial	Crack Length, In. Final*	Environmental Crack Growth, In.	Stress-Intensity Calculations K_{Ii}, ksi $\sqrt{In.}$	Stress-Intensity Calculations K_{If}, ksi $\sqrt{In.}$	Plane-Strain Fracture Toughness K_{Ic}, ksi $\sqrt{In.}$
1.000	411185	SL1	0.029	0.883	0.951	0.068	29.7	26.8	----
		SL2	0.031	0.880	0.942	0.062	31.9	25.8	
2.000	411186	SL1	0.033	0.942	1.029	0.087	30.9	27.2	23.9
		SL2	0.031	0.858	0.937	0.079	33.0	29.2	
2.000	410778	SL1	0.030	0.806	0.935	0.129	34.8	28.4	25.6
		SL2	0.031	0.878	0.956	0.078	32.0	28.4	
4.000	410777	SL1	0.031	0.774	0.839	0.064	38.0	34.1	25.4
		SL2	0.031	0.854	0.928	0.071	33.1	29.6	
4.000	411187	SL1	0.030	0.766	0.846	0.080	37.3	32.6	23.6
		SL2	0.029	0.839	0.876	0.037	31.9	30.1	
6.000	411300	SL1	0.030	0.838	0.874	0.036	38.0	31.2	24.7
		SL2	0.028	0.832	0.860	0.028	31.1	29.7	

Note: Test Specimen: Short-transverse (S-L) double cantilever beam bolt loaded to pop-in.
Test Environment: Air at 80°F, 45% R.H. plus 3.5% NaCl dropwise three times a day for 30 days.

* Includes both the mechanical precrack and the environmental crack growth.

TABLE LII

RESULTS OF SCC TESTS OF PRECRACKED SPECIMENS FROM 7050-T736 DIE FORGINGS (NASC CONTRACT NO. N00019-72-C-0512)

Sample Thickness, In.	Sample Number	Die No.	Test Specimen	C.O.D., Inches	Crack Length, Inches Initial	Crack Length, Inches Final*	Environmental Crack Growth, Inches	Stress-Intensity Calculations K_{Ii}, ksi $\sqrt{In.}$	Stress-Intensity Calculations K_{If}, ksi $\sqrt{In.}$	Plane-Strain Fracture Toughness K_{Ic}, ksi $\sqrt{In.}$
1.001 - 2.000	411351	15789	SL1 SL2	0.027 0.025	0.898 0.949	1.115 1.122	0.217 0.173	27.0 23.1	19.8 18.1	26.0
1.001 - 2.000	411281	17975	SL1 SL2	0.022 0.020	0.659+ 0.713	0.791+ 0.866	0.132 0.148	33.2 27.0	26.2 21.0	24.2
2.001 - 4.000**	411392	1364	SL1 SL2	0.021 0.026	0.819 0.684+	0.966 0.786+	0.147 0.102	25.8 37.4	19.0 31.2	23.3
2.001 - 4.000	411332	8457	SL1 SL2	0.013 0.020	0.792 0.876	1.023 1.100	0.231 0.224	21.4 20.7	14.9 14.9	23.4#
4.001 - 5.000	411233	12767	SL1 SL2	0.023 0.019	0.901 0.843	1.302 1.212	0.401 0.369	22.9 20.7	13.3 12.3	33.2# 29.1#
6.001 - 7.000	411303	16392	SL1 SL2	0.020 0.021	0.894 0.883	1.205 1.213	0.301 0.330	20.1 21.5	13.0 13.5	21.2

Note: Test Specimen: Short-transverse (S-L) double cantilever beam bolt loaded to pop-in.
Test Environment: Air at 80°F, 45% R.H. plus 3.5% NaCl dropwise three times a day for 30 days.

* Includes both the mechanical precrack and the environmental crack growth.

\+ Crack front showed considerable deviation from intended plane of fracture.

\# Did not meet ASTM criteria for valid K_{Ic} values.

** Producer B, all others from Producer A.

TABLE LIII

RESULTS OF SCC TESTS OF PRECRACKED SPECIMENS FROM 7050-T76511 EXTRUDED SHAPES
(NASC CONTRACT NO. N00019-72-C-0512)

Sample Thickness or Size, In.	Sample Number	Test Specimen	C.O.D. In.	Crack Length, In. Initial	Crack Length, In. Final*	Environmental Crack Growth, In.	Stress-Intensity Calculations K_{Ii}, ksi $\sqrt{In.}$	Stress-Intensity Calculations K_{If}, ksi $\sqrt{In.}$	Plane-Strain Fracture Toughness K_{Ic}, ksi $\sqrt{In.}$
1.161	411287	SL1	0.022	0.888	1.231	0.343	22.4	13.9	----
		SL2	0.020	0.823	1.154	0.331	22.5	13.9	
1.5 x 7.5	411284	SL1	0.020	0.839	1.260	0.421	22.0	12.2	22.2
		SL2	0.021	0.820	1.255	0.435	23.8	12.9	
2.0 x 8.0 **	411279	SL1	0.015	0.838	1.010	0.172	20.9	16.1	18.2
		SL2	0.020	0.858	1.016	0.158	21.3	16.8	
3.5 x 7.5	411295	SL1	0.017	0.846	1.186	0.340	18.5	11.4	16.4
		SL2	0.016	0.818	1.150	0.332	18.2	11.2	
4.0 x 8.0 **	411280	SL1	0.017	0.809	1.004	0.195	19.6	14.5	18.2
		SL2	0.018	0.810	1.027	0.217	20.8	14.9	
5 x 6.25	411286	SL1	0.018	0.854	1.129	0.257	19.3	12.9	18.0
		SL2	0.018	0.840	1.108	0.268	19.7	13.3	

Notes: Test Specimen: Short-transverse (S-L) double cantilever beam bolt loaded to pop-in.
Test Environment: Air at 80°F, 45° R.H. plus 3.5% NaCl dropwise three times a day for 30 days.

* Includes both the mechanical precrack and the environmental crack growth.

** Producer B, all others from Producer A.

Table LIV

RESULTS OF TESTS OF RING LOADED SHORT TRANSVERSE COMPACT SPECIMENS OF 7050-T73651 PLATE AND 7050-T76511 EXTRUDED SHAPES

	Initial Values							Values at Fracture					
	Target				Calculated (b)			Estimated		Calculated (b)			
Specimen Number	Crack Length in. (a)	Load lb.	K_{Ii} ksi $\sqrt{in.}$	$\%K_{Ic}$	Crack Length in.	Load lb.	K_{Ii} ksi $\sqrt{in.}$	Crack Length in. (c)	K_{If} ksi $\sqrt{in.}$	Crack Length in.	Load lb.	K_{If} ksi $\sqrt{in.}$	Time to Failure hrs.
7050-T73651 Plate (S. No. 410777)													
S-L-1	1.005	3660	25.0	98	1.062 (d)	3660	27.4 (d)	1.060	27.2	1.089 (d)	3650	28.5 (d)	120
S-L-2	1.010	3330	22.9	90	1.048	3330	24.3	1.250	33.9	1.237	3200	33.0	1704
S-L-3	1.010	3140	21.6	85	1.034	3140	22.4	1.250	31.9	1.211	3010	29.4	3120
S-L-4	1.000	2790	19.0	75	1.038	2790	20.1	----	----	1.178 (e)	2710 (e)	24.9 (e)	3600
7050-T76511 Extruded Shape (S. No. 411286)													
S-L-1	1.000	2120	14.4	80	1.038	2130	15.3	1.096	16.6	1.115	2110	17.2	120
S-L-2	1.005	1850	12.6	70	1.078	1850	14.2	1.310	21.0	1.328	1730	21.9	540
S-L-3	1.005	1570	10.8	60	1.030	1570	11.2	1.323	18.3	1.333	1450	18.7	822
S-L-4	1.000	1325	9.0	50	1.034	1330	9.5	1.405	17.6	1.405	1145	19.8	2860

(a) Initial crack lengths were averages of measurements on both sides of specimen.
(b) Calculated values based on measurements of loads and crack opening displacements.
(c) Final crack lengths measured on fracture surfaces.
(d) Relatively high calculated values may be due to plastic deformation during loading.
(e) Test terminated before specimen failed.

APPENDIX

Table LV

FATIGUE CRACK-GROWTH DATA FOR 7050-T76 SHEET
Constant Load Tests, Stress Ratio = +1/3
NASC Contract N00019-72-C-0512

CYCLES	FATIGUE CRACK LENGTH (IN.) AVG. LEFT	AVG. RIGHT	TOTAL NOTCH LENGTH (IN.)	PERCENT CRACKED
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CYCLES	FATIGUE CRACK LENGTH (IN.) AVG. LEFT	AVG. RIGHT	TOTAL NOTCH LENGTH (IN.)	PERCENT CRACKED
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CYCLES	FATIGUE CRACK LENGTH (IN.) AVG. LEFT	AVG. RIGHT	TOTAL NOTCH LENGTH (IN.)	PERCENT CRACKED
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CYCLES	FATIGUE CRACK LENGTH (IN.) AVG. LEFT	AVG. RIGHT	TOTAL NOTCH LENGTH (IN.)	PERCENT CRACKED
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CYCLES	FATIGUE CRACK LENGTH (IN.) AVG. LEFT	AVG. RIGHT	TOTAL NOTCH LENGTH (IN.)	PERCENT CRACKED
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CYCLES	FATIGUE CRACK LENGTH (IN.) AVG. LEFT	AVG. RIGHT	TOTAL NOTCH LENGTH (IN.)	PERCENT CRACKED
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Notes: CN = Center Notch Specimen, Fig. 41
Crack lengths are average readings on front and back surface. Total notch length includes machined flaw of 0.20.
T = Specimen thickness

Table LV (conc.)

FATIGUE CRACK-GROWTH DATA FOR 7050-T76 SHEET
Constant Load Tests, Stress Ratio = +1/3
NASC Contract N00019-72-C-0512

CYCLES	FATIGUE CRACK LENGTH (IN.) AVG. LEFT	AVG. RIGHT	TOTAL NOTCH LENGTH (IN.)	PERCENT CHANGE
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CYCLES	FATIGUE CRACK LENGTH (IN.) AVG. LEFT	AVG. RIGHT	TOTAL NOTCH LENGTH (IN.)	PERCENT CHANGE
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CYCLES	FATIGUE CRACK LENGTH (IN.) AVG. LEFT	AVG. RIGHT	TOTAL NOTCH LENGTH (IN.)	PERCENT CHANGE
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Notes: CN = Center Notch Specimen, Fig. 41
Crack lengths are average readings on front and back surface. Total notch length includes machined flaw of 0.20.
T = specimen thickness.

Table LVI

FATIGUE CRACK-GROWTH DATA FOR 7050-T73651 PLATE
Constant Load Tests, Stress Ratio = +1/3
NASC Contract N00019-72-C-0512

[illegible]

Notes: CT = Compact tension crack growth specimen, Fig. 42.
Crack lengths measured from load line.

T = Specimen thickness.

Table LVI (conc.)

FATIGUE CRACK-GROWTH DATA FOR 7050-T73651 PLATE
Constant Load Tests, Stress Ratio = +1/3
NASC Contract N00019-72-C-0512

Notes: CT = Compact tension crack growth specimen, Fig. 42.
Crack lengths measured from load line.

T = Specimen thickness.

Table LVII

FATIGUE CRACK-GROWTH DATA FOR 7050-T73652 HAND FORGING
Constant Load Tests, Stress Ratio = +1/3
NASC Contract N00019-72-C-0512

[illegible]

	FATIGUE CRACK LENGTH (IN.)		PERCENT
CYCLES	FRONT	BACK	CRACKED
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

	FATIGUE CRACK LENGTH (IN.)		PERCENT
CYCLES	FRONT	BACK	CRACKED
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

	FATIGUE CRACK LENGTH (IN.)		PERCENT
CYCLES	FRONT	BACK	CRACKED
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

	FATIGUE CRACK LENGTH (IN.)		PERCENT
CYCLES	FRONT	BACK	CRACKED
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

	FATIGUE CRACK LENGTH (IN.)		PERCENT
CYCLES	FRONT	BACK	CRACKED
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

	FATIGUE CRACK LENGTH (IN.)		PERCENT
CYCLES	FRONT	BACK	CRACKED
[illegible]	[illegible]	[illegible]	[illegible]

Notes: CT = Compact tension crack growth specimen, Fig. 42. Crack lengths measured from load line.

T = Specimen thickness.

Table LVII (conc.)

FATIGUE CRACK-GROWTH DATA FOR 7050-T73652 HAND FORGING
Constant Load Tests, Stress Ratio = +1/3
NASC Contract N00019-72-C-0512

Notes: CT = Compact tension crack growth specimen, Fig. 42.
Crack lengths measured from load line.

T = Specimen thickness.

Table LVIII

FATIGUE CRACK-GROWTH DATA FOR 7050-T76511 EXTRUDED SHAPES
Constant Load Tests, Stress Ratio = +1/3
NASC Contract N00019-72-C-0512

[illegible]	[illegible]	[illegible]	[illegible]

Notes: CT = Compact Tension Crack Growth Specimen, Fig. 42. Crack lengths measured from load line.
T = specimen thickness.

Table LVIII (conc.)

FATIGUE CRACK-GROWTH DATA FOR 7050-T76511 EXTRUDED SHAPES
Constant Load Tests, Stress Ratio = +1/3
NASC Contract N00019-72-C-0512

[illegible]

Notes: CT = Compact Tension Crack Growth Specimen, Fig. 42.
Crack lengths measured from load line.
T = specimen thickness.